PB-240 068

RADIOLOGICAL HEALTH DATA AND REPORTS. VOLUME 10, NUMBERS 4-6, APRIL - JUNE 1969

Public Health Service
Washington, D. C.

June 1969

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BIBLIOGRAPHIC DATA SHEET

1. Report No. RHDR 10 (4-6)

2.

PB 240 068

4. Title and Subtitle
Radiological Health Data and Reports
Volume 10, Nos 4-6

5. Report Date
Apr-June 1969

6.

7. Author(s)
None

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Department of Health, Education, and Welfare
Public Health Service
Washington, D. C. 20201

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

13. Type of Report & Period Covered
Final: Apr-June 1969

14.

15. Supplementary Notes

16. Abstracts

Data and interpretation of data on radiation exposure to humans and on radioactivity in milk, water, air, and other environmental media are presented. in 24 volumes. For prices of individual issues, see below:

17. Key Words and Document Analysis. 17a. Descriptors

Radiation
Radioactivity
Air
Water
Milk
Food
Human

17b. Identifiers/Open-Ended Terms

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NATIONAL TECHNICAL
INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

PRICES SUBJECT TO CHANGE

17c. COSATI Field/Group

18. Availability Statement
Release unlimited

1

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page
UNCLASSIFIED

21. No. of Pages
152

22. Price PC/MF
6.25/2.25

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 4, April 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

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RADIOLOGICAL
HEALTH DATA
AND REPORTS

Published under the direction of

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Acting Director
Bureau of Radiological Health

by the Office of Criteria and Standards
Donald L. Snow, Chief

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Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, Bureau of Radiological Health, 12720 Twinbrook Parkway, Rockville, Md. 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration • Bureau of Radiological Health

Disposal of Radioactive Wastes From U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1967

M. E. Miles and *J. J. Mangeno*[1]

This report summarizes data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm the adequacy of waste disposal limits and procedures. The waste disposal data show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships totaled 0.39 curies in 1966 and 0.11 curies in 1967 for all harbors, which is less than the average of 4 curies reported discharged per year during the preceding 5 years. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt-60 have shown that, (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase over the general background radioactivity of the environment, and (3) low-level cobalt-60 radioactivity is detectable in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships have been conducted over a period of several years.

This report confirms that procedures used by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public.

A detailed description of the means of disposing of radioactive wastes and the sources of these wastes has been presented earlier (*1*). Table 1, which updates information in previous reports (1–2) lists the total amount of long-lived radioactivity discharged as liquid wastes into various harbors during the past 5 years. Solid radioactive materials from ships are transferred to a shipyard or other shore facility for packaging and disposal. For ultimate disposal, solid radioactive wastes are shipped to AEC or State-approved burial sites since shipyards and shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. The total radioactivity and volumes of solid radioactive wastes disposed of from 1963 through 1967 are shown in table 2.

Environmental monitoring survey procedures have been described in a previous report (*1*). A summary of the 1967 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled or built is presented in table 3.

Once each quarter, a total of at least five water samples is taken at various locations in each harbor in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross radioactivity and for cobalt-60. No harbor water sample has shown detectable cobalt-60 radioactivity. No increases in gross radioactivity of harbor water have been detected.

Monitoring for cobalt-60 in harbor bottom sediment is conducted each quarter year by collecting 20 to 100 samples with a 6-inch square sampler. Samples are taken of the top one-half to one inch of sediment in the immediate vicinity of and away from berthing areas used by Naval nuclear-powered ships. These surveys show that the total amount of cobalt-60 observed in bottom sediment near a few piers is small compared to natural radioactivity present in harbors.

Samples from each of these harbors are also checked at least annually by a U.S. Atomic Energy Commission (USAEC) laboratory to ensure that analytical procedures are correct and standardized. In addition, the U.S. Navy co-

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[1] Nuclear Power Directorate, Naval Ship Systems Command, Department of the Navy.

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Table 1. Radioactive liquid waste discharges to harbors from U.S. Naval nuclear-powered ships and their support facilities for 1963 through 1967[a]

Location[b,c]	1963		1964		1965		1966		1967	
	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies
Portsmouth, N.H; Naval Shipyard	112	0.03	407	0.13	204	0.24	155	0.01	265	0.01
Quincy, Mass; Quincy Division	104	.09		[d]ND		ND		ND		ND
Groton-New London, Conn; Electric Boat Div., State Pier and Submarine base	101	1.69	201	1.93	828	1.29	1,274	.03	606	.01
Newport News, Va; Newport News Shipbuilding	21	.01	965	.24	3,360	1.70	1,581	.06	1,533	.04
Norfolk, Va; Naval Shipyard and base	300	.07	337	.61	1,146	.44	1,051	.03	1,784	.03
Charleston, S.C; Naval Shipyard and base	246	.14	294	.36	717	.67	369	.04	320	.01
Pascagoula, Miss; Ingalls Shipbuilding Corp.		ND		ND		ND		ND		ND
San Diego, Calif; Navy Pier at Ballast Point	34	.25	35	.40	40	.33		ND		ND
Long Beach, Calif; Naval Shipyard and base		ND		ND		ND		ND		ND
Vallejo, Calif; San Francisco Bay Naval Shipyard	65	.55	63	.62	128	.21	270	.19		ND
Bremerton, Wash; Puget Sound Naval Shipyard	1	.02		ND	196	.01		ND		ND
Pearl Harbor, Hawaii; Naval Shipyard and base	594	.92	405	.98	548	.48	654	.03	683	.01
Apra Harbor, Guam		ND		ND	69	.01		ND		ND
Total	1,578	3.77	2,707	5.27	7,236	5.38	5,354	0.39	5,191	0.11

[a] Radioactivity data are reported as if the entire radioactivity consisted of cobalt-60. Volumes are reported prior to dilution.

[b] For all other harbors in the U.S. and the rest of the world the discharge totaled 180,000 gallons containing a radioactivity of 0.013 curies in 1966 and 16,000 gallons containing 0.001 curies in 1967.

[c] New York Shipbuilding Corporation discharged a total of 0.01 curies into the river at Camden, N.J., from 1960 through June 1967 when all work on U.S. Naval nuclear-powered ships was discontinued.

[d] When discharges in a harbor for a year totaled less than 0.005 curies, ND is reported.

Table 2. Radioactive solid waste disposed of by facilities supporting U.S. Naval nuclear-powered ships for 1963 through 1967[a]

Facility	1963		1964		1965		1966		1967	
	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies
Portsmouth, N.H; Naval Shipyard	15	0.5	80	2.6	150	2.6	194	9.5	300	198.1
Quincy Mass; Electric Boat Division		[b]ND		ND		ND		ND		ND
Groton-New London, Conn.; Electric Boat Div., Tender at State Pier and Submarine base	102	1.1	99	2.3	155	353.0	148	1,092.8	46	17.0
Newport News, Va; Newport News Shipbuilding	8	.3	22	1.8	198	28.0	70	8.9	167	701.9
Norfolk, Va; Naval Shipyard and tender	3	ND	5	.5	33	1.6	43	2.5	108	85.6
Charleston, S.C.: Naval Shipyard and tenders	35	.4	47	1.0	78	111.5	77	5.6	151	52.0
Pascagoula, Miss; Ingalls Shipbuilding Corp.		ND		ND		ND		ND		ND
San Diego, Calif; Tenders at Ballast Point	2	.1	7	7.5	3	ND	6	0.1	7	0.2
Long Beach, Calif; Naval Shipyard and base		ND		ND		ND		ND		ND
Vallejo, Calif. San Francisco Bay Naval Shipyard	35	19.0	9	.3	47	9.4	90	367.0	92	22.8
Bremerton, Wash; Puget Sound Naval Shipyard		ND		ND	4	.1	14	0.5	141	192.8 0
Pearl Harbor, Hawaii; Naval Shipyard and base	16	.4	13	.7	8	1.4	7	0.3	11	1.0
Total	216	21.8	282	16.7	676	507.6	641	1,487.2	1,023	1,271.4

[a] This table includes waste from tenders and nuclear-powered ships since such waste is transferred to these facilities for disposal.

[b] Where total radioactivity is less than 0.05 curies, ND is reported.

operates with the U.S. Public Health Service (USPHS) surveys in some U.S. harbors. Results reported in table 3 are consistent with these USAEC and USPHS checks.

Twice per year shoreline areas uncovered at low tide are surveyed for radiation levels with sensitive radiation detectors to determine if any radioactivity from bottom sediment washed ashore. All results were in the range of 0.01 to 0.05 millirem per hour, the same as background radiation levels in similar areas. Thus there is no evidence in these ports that radioactivity from sediment is washing ashore.

Throughout the year film badges are posted at locations outside the boundaries of areas where radioactive work is performed. These films showed that radiation exposure to the general public outside these facilities was not above that received from natural background radiation levels.

In addition to the locations listed in table 3, environmental monitoring has been accomplished by the U.S. Navy submarine tenders which serve as operating bases for U.S. Naval nuclear-powered submarines in Rota, Spain, and Holy Loch, Scotland. Results of the surveys in the harbor at Rota, Spain, have not shown detectable

Table 3. Summary of 1967 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled, or built

Location	Number of samples with cobalt-60 concentration of: [a]			Total bottom area with cobalt-60 over 10 pCi/cm^2 (km^2)	Estimated total cobalt-60 in top layer of sediment [b] (Ci)
	<10 pCi/cm^2	10-100 pCi/cm^2	> 100 pCi/cm^2		
Portsmouth, N.H. Naval Shipyard	176	0	0	0	ND
Quincy, Mass. Quincy Division	42	0	0	0	ND
Groton-New London, Conn. Electric Boat Div., State Pier, and Submarine base	108	237	50	0.3	2.0
Camden, N.J. (final survey) New York Shipbuilding Corp.	34	0	0	0	ND
Newport News, Va. Newport News Shipbuilding	134	13	1	0.004	0.02
Norfolk, Va., Naval Shipyard and base	344	0	0	0	ND
Charleston, S.C., Naval Shipyard and base	380	0	0	0	ND
Pascagoula, Miss., Ingalls Shipbuilding Corp.	80	0	0	0	ND
San Diego, Calif., Navy Pier at Ballast Point	161	10	0	0.01	ND
Long Beach, Calif., Naval Shipyard and base	155	1	0	0	ND
Vallejo, Calif., San Francisco Bay Naval Shipyard	443	0	0	0	ND
Bremerton, Wash., Puget Sound Naval Shipyard	140	0	0	0	ND
Pearl Harbor, Hawaii, Naval Shipyard and base	205	79	4	0.3	0.05
Apra Harbor, Guam	100	0	0	0	ND

[a] Minimum detectable radioactivity is approximately 2 pCi/cm^2. Results in units of pCi/g are approximately half the value in pCi/cm^2.

[b] Total is from areas with cobalt-60 over 10 pCi/cm^2, which were in the immediate vicinity of piers used for berthing nuclear-powered ships. Where total cobalt-60 is less than 0.01 curie, ND is reported. Coresamples more than 1-foot deep from several harbors show that total cobalt-60 present may be two to five times than measured in the surface layer.

cobalt-60 in harbor bottom sediment samples. In 1965 in Holy Loch, more cobalt-60 radioactivity than expected was detected in harbor bottom sediment and on shoreline mud flat areas uncovered at low tide. However, there had been no increase of harbor water radioactivity in Holy Loch above normal background levels. Joint U.S. and British assessments of survey results confirmed that radiation levels in the vicinity of the Holy Loch anchorage were far below those which were at all likely to cause an individual to receive radiation exposure approaching limits for members of the general public. Environmental monitoring during 1967 showed radioactivity levels in Holy Loch are steadily declining.

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(1) VAUGHAN, J. W. and M. E. MILES. Disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1965. Radiol Health Data Rep 7:257-262 (May 1966).

(2) MILES, M. E. and J. J. MANGENO. Disposal of radioactive wastes from U.S. Naval nuclear powered ships and their support facilities, 1966. Radiol Health Data Rep 8:699-701 (December 1967).

Data

SECTION I. MILK AND FOOD

Milk Surveillance, December 1968

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents

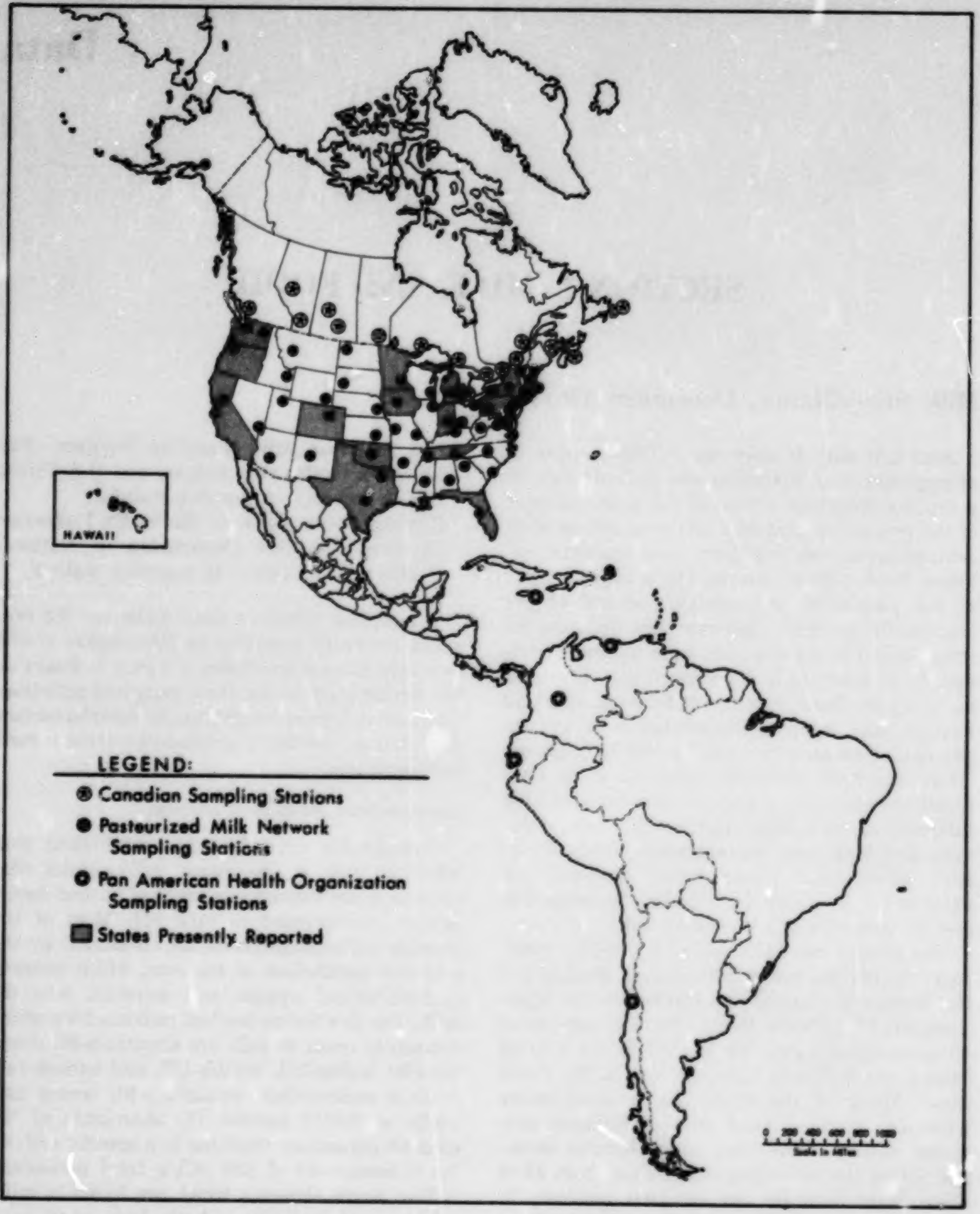
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
⊙ Pan American Health Organization Sampling Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere reported in ***Radiological Health Data and Reports***

of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation expressed in terms of 2 standard deviations for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation will also reflect whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention

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was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviations
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/yr)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)	Range II (pCi/day)	Range III (pCi/day)
Strontium-89	Bone	1.5	0.5	[b]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1[illegible]	.5	[b]200	0-20	20-200	200-2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[c]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[c] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first year total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000
Strontium-90	Bone marrow			[c]51,000
Cesium-137	Whole body			[c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 34,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

Table 3. Concentration of radionuclides in milk for December 1968 and 12-month period, January through December 1968

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	7	8	0(4)	0	12(4)	14
Alaska:	Palmer[c]	P	5	5	0(4)	0	10(4)	12
Ariz:	Phoenix[c]	P	0	1	0(4)	0	0(4)	2
Ark:	Little Rock[c]	P	18	21	0(4)	0	21(4)	19
Calif:	Sacramento[c]	P	0	2	0(4)	0	0(4)	5
	San Francisco[c]	P	3	2	0(4)	0	0(4)	3
	Del Norte	P	20	21	0	0	0	22
	Fresno	P	0	0	0	0	0	5
	Humboldt	P	5	4	0	0	15	13
	Los Angeles	P	0	1	0	0	0	0
	Mendocino	P	3	3	0	0	0	4
	Sacramento	P	3	2	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	6
	Shasta	P	3	4	0	0	0	4
	Sonoma	P	0	2	0	0	0	4
Colo:	Denver[c]	P	7	5	0(3)	0	0(3)	6
	West	R	(e)		(e)	(e)	(e)	(e)
	Northeast	R	(e)		(e) (3)	1	(e)	(e)
	East	R	(e)		(e)	(e)	(e)	(e)
	Southeast	R	(e)		NS	(e)	NS	(e)
	South Central	R	(e)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	8	10	0(4)	0	16(4)	12
	Central	P	7	7	4(3)	0	4(3)	10
Del:	Wilmington[c]	P	9	10	0(4)	0	7(4)	8
D.C:	Washington[c]	P	6	9	0(3)	0	11(3)	6
Fla:	Tampa[c]	P	9	8	0(3)	0	58(3)	66
	West	R	7	14	0	3	35	33
	North	R	18	14	0	0	57	35
	Northeast	R	7	8	0	2	36	31
	Central	R	NA	9	0	2	52	55
	Tampa Bay area	R	10	8	0	0	70	71
	Southeast	R	8	9	0	0	81	100
Ga:	Atlanta[c]	P	13	14	0(4)	0	18(4)	20
Hawaii:	Honolulu[c]	P	5	4	0(3)	1	0(3)	3
Idaho:	Idaho Falls[c]	P	4	6	0(3)	0	10(3)	9
Ill:	Chicago[c]	P	10	9	0(5)	0	12(5)	10
Ind:	Indianapolis[c]	P	8	8	0(5)	0	11(5)	7
	Northeast	P	8	11	0	0	15	11
	Southeast	P	12	11	0	0	15	12
	Central	P	15	9	0	0	0	9
	Southwest	P	13	10	0	0	20	13
	Northwest	P	17	10	0	0	15	12
Iowa:	Des Moines[c]	P	5	7	0(3)	0	1(3)	6
	Iowa City	P	6(2)	7	0(2)	0	8(2)	5
	Des Moines	P	4(5)	7	0(5)	0	5(5)	3
	Spencer	P	5	6	0	0	13	4
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	7	8	0(5)	0	3(5)	4
Ky:	Louisville[c]	P	9	12	0(3)	0	2(3)	6
La:	New Orleans[c]	P	15	20	0	0	21	23
Maine:	Portland[c]	P	14	12	1(5)	1	35(5)	28
Md:	Baltimore[c]	P	9	10	0(5)	0	10(5)	7
Mass:	Boston[c]	P	12	12	0(5)	0	17(5)	24
Mich:	Detroit[c]	P	9	9	0(5)	0	7(5)	11
	Grand Rapids[c]	P	12	11	0(4)	0	18(4)	15
	Bay City	P	NS	4	NS	0	NS	6
	Charlevoix	P	NA	5	(e)	(e)	0	8
	Detroit	P	6	4	(e) (5)	(e)	4(5)	5
	Grand Rapids	P	6(3)	5	(e) (4)	(e)	6(4)	7
	Lansing	P	5(3)	4	(e) (3)	(e)	8(3)	3
	Marquette	P	10	7	(e) (3)	(e)	34(3)	24
	Monroe	P	4	3	8(2)	(e)	0(2)	1
Minn:	Minneapolis[c]	P	10	11	0(7)	0	11(7)	13
	Bemidji	P	17	15	0	0	22	23
	Mankato	P	6	6	0	0	0	0
	Rochester	P	9	9	0	0	13	0
	Duluth	P	16	19	0	0	21	30
	Worthington	P	9	6	0	0	0	0
	Minneapolis	P	14	12	0	0	0	13
	Fergus Falls	P	9	10	0	0	0	0
	Little Falls	P	13	10	0	0	0	14
Miss:	Jackson[c]	P	16	17	0(5)	0	15(5)	15
Mo.:	Kansas City[c]	P	0	7	0(4)	0	5(4)	5
	St. Louis[c]	P	8	9	0(3)	0	4(3)	7
Mont:	Helena[c]	P	6	5	0(3)	0	13(3)	8
Nebr:	Omaha[c]	P	7	7	0(4)	0	5(4)	6
Nev:	Las Vegas[c]	P	0	1	0(3)	0	2(3)	4
N.H:	Manchester[c]	P	9	13	0(5)	0	37(5)	35
N.J:	Trenton[c]	P	10	10	0(3)	0	11(3)	10
N. Mex:	Albuquerque[c]	P	0	3	0(5)	0	5(5)	2

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for December 1968 and 12-month period, January through December 1968—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.Y:	Buffalo*	P	6	8	0(4)	0	14(4)	10
	New York City*	P	9	12	0(5)	0	18(5)	15
	Syracuse*	P	9	9	0(4)	0	12(4)	7
	Albany	P	10(10)	8	0(4)	0	(*) (4)	(*)
	Buffalo	P	NA	7	NA	0	NA	(*)
	Massena	P	11(2)	11	0(2)	0	23(2)	23
	Newburgh	P	14(4)	10	0(4)	0	(*) (4)	(*)
	New York City	P	13(4)	13	0(4)	0	16(4)	(*)
	Syracuse	P	11(3)	7	0(3)	0	(*) (3)	(*)
N.C:	Charlotte*	P	16	15	0(4)	1	13(4)	13
N. Dak:	Minot*	P	10	11	0(6)	0	17(6)	13
Ohio:	Cincinnati*	P	9	9	0(4)	0	3(4)	5
	Cleveland*	P	8	9	0(4)	0	10(4)	8
Okla:	Oklahoma City*	P	8	10	0(3)	0	16(3)	6
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland*	P	7	8	0(6)	0	6(6)	15
	Baker	P	NA	4	(*)	(*)	16	5
	Coos Bay	P	NA	10	(*)	(*)	18	3
	Eugene	P	NA	3	(*)	(*)	20	13
	Medford	P	NA	3	(*)	(*)	(*)	9
	Portland composite	P	NA	7	(*)	(*)	18	8
	Portland local	P	NA	5	(*)	(*)	16	9
	Redmond	R	NA	4	(*)	(*)	(*)	5
	Tillamook	P	NA	10	(*)	(*)	18	25
Pa:	Philadelphia*	P	8	10	0(4)	0	6(4)	9
	Pittsburgh*	P	14	13	0(5)	0	6(4)	13
	Dauphin	P	6	8	0	0	0	16
	Erie	P	NA	13	0	0	NA	22
	Philadelphia	P	13(3)	10	0	0	18(3)	18
	Pittsburgh	P	14(5)	12	0	0	18(5)	18
R.I:	Providence*	P	8	11	0(4)	0	18(4)	19
S.C:	Charleston*	P	11	14	0(3)	0	23(3)	20
S. Dak:	Rapid City*	P	6	9	0(7)	0	16(7)	11
Tenn:	Chattanooga*	P	12	13	0(4)	0	14(4)	13
	Memphis*	P	8	11	0(4)	0	10(4)	6
	Chattanooga	P	11	12	0(4)	0	18(4)	17
	Clinton	P	13	13	0(2)	0	14(2)	20
	Knoxville	P	9	11	0(5)	3	18(5)	16
	Nashville	P	8	8	0(3)	0	8(3)	11
Tex:	Austin*	P	0	3	0(4)	0	4(4)	2
	Dallas*	P	5	8	0(5)	0	4(5)	6
	Amarillo	R	2	4	0	0	0	2
	Corpus Christi	R	NS	4	NS	0	NS	0
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	NS	7	NS	0	NS	0
	Harlingen	R	2	4	0	0	0	0
	Houston	R	NS	11	NS	0	NS	14
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	NS	3	NS	0	NS	0
	San Antonio	R	2	3	0	0	0	0
	Texarkana	R	9	12	0	0	15	16
	Uvalde	R	NS	3	NS	0	NS	0
	Wichita Falls	R	NS	10	NS	0	NS	0
Utah:	Salt Lake City*	P	4	5	0(6)	0	11(6)	13
Vt:	Burlington*	P	10	11	0(5)	0	19(5)	10
Va:	Norfolk*	P	10	11	0(4)	0	2(4)	9
Wash:	Seattle*	P	8	8	0(7)	0	11(7)	22
	Spokane*	P	7	8	0(8)	0	13(8)	10
	Benton County	R	NS	0	NS	0	NS	5
	Deer Park	R	4	3	0	0	(*)	3
	Elma	R	5	5	0	0	(*)	12
	Franklin County	R	0	0	0	0	(*)	(*)
	Moses Lake	R	0	1	0	0	(*)	(*)
	Pierce County	R	5	4	0	0	(*)	9
	Sandpoint, Idaho	R	9	8	0	0	35	23
	Skagit County	R	4	4	0	0	(*)	12
W.Va:	Charleston*	P	9	12	0(3)	0	4(3)	5
Wis:	Milwaukee*	P	7	8	0(4)	0	13(4)	11
Wyo:	Laramie*	P	6	4	0(3)	0	16(3)	19
CANADA								
Alberta:	Calgary	R	6	8	(*)		16	19
	Edmonton	R	8	8	(*)		26	22
British Columbia:	Vancouver	R	14	14	(*)		50	51
Manitoba:	Winnipeg	R	8	8	(*)		22	25
New Brunswick:	Fredericton	R	12	15	(*)		29	28

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for December 1968 and 12-month period, January through December 1968—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA—Continued								
Newfoundland:	St. Johns	R	15	21	(d)		40	44
Nova Scotia:	Halifax	R	8	12	(d)		23	24
Ontario:	Ft. William	R	13	16	(d)		28	31
	Ottawa	R	8	9	(d)		18	20
	Sault Ste. Marie	R	16	15	(d)		25	23
	Toronto	R	4	5	(d)		24	17
	Windsor	R	5	6	(d)		19	14
Quebec:	Montreal	R	9	10	(d)		20	21
	Quebec	R	10	13	(d)		29	29
Saskatchewan:	Regina	R	6	8	(d)		16	17
	Saskatoon	R	11	9	(d)		21	19
CENTRAL AND SOUTH AMERICA								
Columbia:	Bogota	P	NS	1	NS	0	NS	2
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Montego Bay	P	7	5	0	0	235	109
Venezuela:	Caracas	P	0	1	0	0	0	0
Canal Zone:	Cristobal [c]	P	0	2	0(5)	1	18(5)	11
Puerto Rico:	San Juan [c]	P	5	4	0(5)	0	4(5)	9
PMN network averages: [f]			6	9	0	0	11	12

[a] P, pasteurized milk; R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter
Washington—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [c].

NA no analysis.

NS, no sample collected.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137, for December 1968 and the 12-month period, January 1968 to December 1968. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for December 1968 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which strontium-89 or barium-140 were detected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of

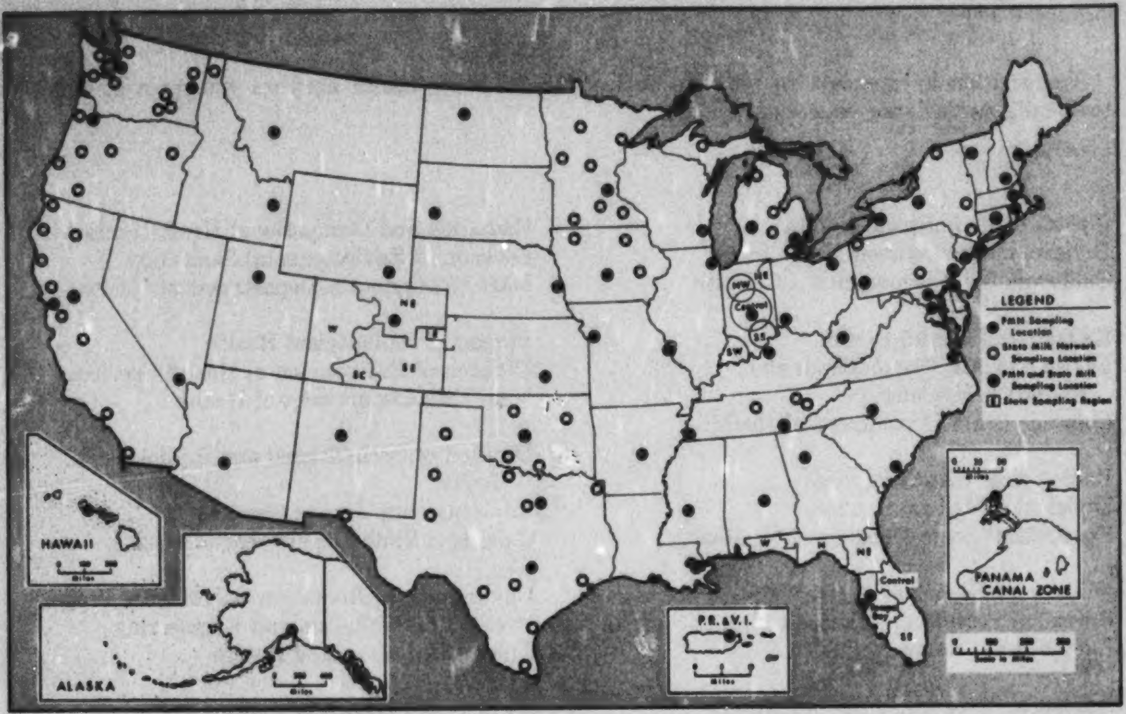
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
Miles
Scale in Miles
NE
W
SE
SC
NW
Central
SW
N
Central
Bay
SE

Figure 2. State and PMN milk sampling locations in the United States

Table 4. Strontium-89 and barium-140 in milk December 1968

Sampling location	Monthly average concentration (pCi/liter)	
	Strontium-89	Barium-140
C. Z: Cristobal (PMN)	8	
Calif: Del Norte (State)	6	
Los Angeles (State)		19
Mendocino (State)		15
Sacramento (State)		13
Sacramento (PMN)		3(4)
Santa Clara (State)		17
Shasta (State)		14
Sonoma (State)		11
Conn: Central (State)		5(3)
Fla: Northeast (State)		16
Central (State)		18
Nebr: Omaha (PMN)		4(4)
Tenn: Clinton (State)	6	

particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 35 pCi/liter in the United States for the month of December 1968 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark., Del Norte, Calif.), representing 10.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 81 pCi/liter in the United States for the month of December 1968 and the highest 12-month average was 109 pCi/liter (Southeast Florida), representing 3.0 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were generally below the practical reporting level. The following station averages reflect samples in which iodine-131 was detected: Central Connecticut (State) 4 pCi/liter, 3 samples; Portland, Maine (PMN) 1 pCi/liter, 5 samples.

Acknowledgment

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and
Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation and Occupational Health Section
Division of Environmental Sanitation
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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FOOD AND DIET SURVEILLANCE

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968

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1. Radionuclides in Institutional Diet Samples
July–September 1968

Bureau of Radiological Health and
Bureau of Community Environmental Management

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated it's Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Bureau of Community Environmental Management (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions, and 8 auxiliary institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1*, *2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period and is then

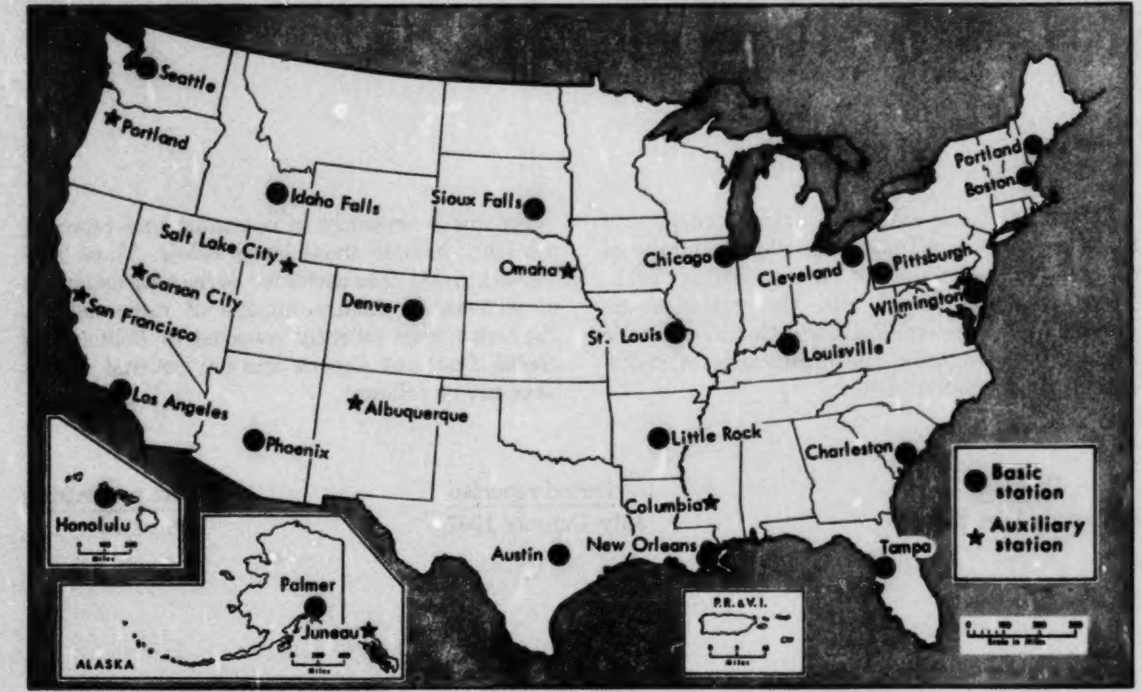
Seattle
Portland
Idaho Falls
Sioux Falls
Salt Lake City
Omaha
Carson City
San Francisco
Denver
Los Angeles
Albuquerque
Phoenix
Chicago
Cleveland
Pittsburgh
Portland
Boston
Wilmington
St. Louis
Louisville
Little Rock
Charleston
Columbia
New Orleans
Austin
Tampa
Honolulu
Palmer
Juneau
ALASKA
P.R. & V.I.
Basic station
Auxiliary station

Figure 1. Institutional diet sampling locations as of July–September 1968

packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from April through June 1968, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in

Table 1. Concentrations and intake of stable elements and radionuclides in Institutional total diets of children (9–12 years of age), July–September 1968

Location of Institution		Month (1968)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137		Radium-226	
				g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska:	Palmer	July	1.33	0.6	0.8	1.3	1.8	11	14	25	33	0.4	0.5
		Aug ᵃ	1.67	.6	.9	1.2	2.0	10	17	23	38	.4	.7
		Sept	1.16	.4	.5	1.3	1.5	7	8	18	21	.5	.6
Ariz:	Phoenix	Aug	1.70	.6	1.1	1.3	2.3	7	12	0	0	.7	1.3
		Sept	1.74	.6	1.0	.9	1.6	5	9	0	0	.7	1.2
Ark:	Little Rock	July	1.65	.5	.8	1.3	2.2	11	19	0	0	.3	.5
		Aug	1.43	.5	.7	1.3	1.8	18	25	11	16	.5	.7
		Sept	1.57	.4	.6	1.4	2.1	7	11	0	0	.5	.8
Calif:	Los Angeles	July	1.46	.5	.7	1.3	1.7	4	6	0	0	.4	.6
		Aug	1.50	.6	.9	1.4	2.1	4	6	0	0	.5	.8
		Sept ᵃ	1.81	.5	.9	1.3	2.1	5	9	0	0	.5	.9
Colo:	Denver	July	2.46	.7	1.8	1.5	3.7	6	14	13	22	.4	1.0
		Aug	2.30	.8	1.8	1.7	3.9	6	15	15	35	.5	1.2
		Sept	2.48	.5	1.3	1.4	3.4	5	13	13	22	.4	1.0
Del:	Wilmington	July	2.07	.7	1.3	1.7	3.4	9	19	11	23	.9	1.9
		Aug	2.16	.7	1.4	1.7	3.6	7	15	14	30	.8	1.7
		Sept	2.04	.6	1.3	1.7	3.5	10	20	0	0	.7	1.4
Fla:	Tampa	July	1.50	.5	.7	1.5	2.2	7	11	34	81	.7	1.1
		Aug	1.54	.5	.7	1.6	2.5	10	15	35	54	.6	.9
		Sept	1.54	.5	.8	1.6	2.5	8	13	32	49	.9	1.4
Hawaii:	Honolulu	July	2.45	.5	1.2	1.5	3.6	5	12	25	61	.6	1.5
		Aug	2.41	.6	1.4	1.3	3.2	4	9	19	46	.5	1.3
		Sept	2.42	.4	1.0	1.2	4.0	4	10	19	46	.5	1.3
Idaho:	Idaho Falls	July ᵃ	2.19	1.0	2.3	1.3	2.9	7	16	20	44	.5	1.1
		Aug ᵃ	1.60	.8	1.4	1.4	2.3	7	13	13	22	.6	1.0
		Sept ᵃ	1.78	1.3	2.3	1.7	3.0	10	16	13	23	.9	1.6
Ill:	Chicago	July ᵃ	1.39	.6	.8	1.7	2.3	7	10	13	17	1.1	1.5
		Aug	NS										
		Sept	NS										
Ky:	Louisville	July	1.62	.5	.8	1.5	2.4	9	14	0	0	.7	1.1
		Aug	1.63	.6	.9	1.7	2.7	6	9	0	0	.6	1.0
		Sept	1.70	.7	1.1	1.6	2.6	11	19	0	0	1.0	1.7
La:	New Orleans	July	1.65	.5	.8	1.8	3.0	11	18	16	26	.4	.7
		Aug	2.08	.5	1.1	1.4	2.9	7	15	12	24	.3	.6
		Sept	1.87	.5	1.0	1.6	3.0	9	16	15	28	.4	.7
Maine:	Portland	July	1.53	.8	1.2	1.5	2.2	16	24	26	40	1.0	1.5
		Aug	1.80	.8	1.4	1.5	2.7	12	22	25	45	.7	1.3
		Sept	1.62	.8	1.3	1.7	2.8	13	21	24	39	.8	1.3
Mass:	Boston	July	1.94	.7	1.4	1.7	3.3	12	24	28	54	.8	1.6
		Aug	1.55	.4	.7	1.6	2.5	8	12	22	34	.8	1.3
		Sept	1.70	.6	1.0	1.4	2.4	9	15	22	37	.5	.9
Mo:	St. Louis	July	2.31	1.2	2.7	1.6	3.6	11	25	0	0	.3	.7
		Aug ᵃ	2.04	1.2	2.5	1.5	3.1	9	18	17	35	.8	1.6
		Sept	2.80	1.1	3.1	1.6	4.5	8	22	18	50	.6	1.7
Ohio:	Cleveland	July	1.57	.7	1.1	1.6	2.6	8	12	13	20	.8	1.3
		Aug	1.65	.9	1.5	1.7	2.8	8	13	16	26	.7	1.2
		Sept	1.22	.6	.7	1.5	1.8	6	7	0	0	.5	.6
Pa:	Pittsburgh	July	2.36	.5	1.2	1.6	3.7	9	21	0	0	.7	1.7
		Aug	2.23	.5	1.2	1.5	3.2	7	16	0	0	.7	1.6
		Sept	2.25	.6	1.2	1.2	2.7	8	18	0	0	.9	2.0
S. C:	Charleston	July	1.52	.7	1.1	1.4	2.1	13	20	20	30	.8	1.2
		Aug	2.17	.6	1.4	1.2	2.5	8	18	20	42	.5	1.1
		Sept	1.53	.7	1.1	1.5	2.3	9	14	21	32	.8	1.2
S. Dak:	Sioux Falls	July	1.06	.9	.9	1.6	1.7	7	8	0	0	.5	.5
		Aug ᵃ	1.27	.8	1.0	1.3	1.6	6	8	18	23	1.4	1.8
		Sept ᵃ	1.73	.7	1.2	1.3	2.2	6	10	12	21	.9	1.6
Tex:	Austin	July	1.81	.7	1.3	1.7	3.0	4	8	0	0	.3	.5
		Aug	1.33	.7	.9	1.5	2.0	5	6	0	0	.3	.4
		Sept	1.91	.9	1.8	1.6	3.0	6	12	0	0	.4	.8
Wash:	Seattle	July	NS										
		Aug ᵃ	2.25	.5	1.1	1.2	2.6	7	15	0	0	.5	1.1
		Sept ᵃ	1.96	.5	1.0	1.5	2.9	6	11	18	35	.7	1.4
Institutional average		July	1.78	0.7	1.2	1.5	2.7	9	16	12	22	0.6	1.0
		Aug	1.82	0.6	1.1	1.5	2.7	8	14	13	24	0.6	1.1
		Sept	1.85	0.6	1.2	1.4	2.7	8	14	11	21	0.6	1.2

ᵃ Since food samples were collected from two or more children who were not between the ages of 9–12, data for this month were not used in institutional average.

NS, no sample.

Note: Since iodine-131, barium-140 and strontium-89 were not detectable at most stations during the third quarter of 1968, no provision was made for these nuclides in the table. The few exceptions are as follows: strontium-89 was reported in July for Idaho, 6 pCi/kg. Barium-140 was reported in July for Massachusetts, 20 pCi/kg. Barium-140 was reported in August for Delaware, 19 pCi/kg and Maine, 14 pCi/kg. Barium-140 was also reported in September for Missouri, 20 pCi/kg; Ohio, 21 pCi/kg; and Pennsylvania, 11 pCi/kg.

Table 2. Concentrations and intake of stable elements and radionuclides in institutional total diets of children July–September 1968

Location of Institution		Month (1968)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137		Radium-226	
				g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska:	Juneau	July	1.22	0.6	0.7	1.5	1.8	8	10	12	16	0.5	0.6
		Aug	1.24	.6	.7	1.6	1.9	11	14	24	30	.5	.6
		Sept	1.22	.6	.7	1.5	1.8	6	7	19	23	.6	.7
Calif:	San Francisco	July	2.39	.5	1.2	1.4	3.4	4	11	11	26	.5	1.2
		Aug	2.22	.7	1.6	1.5	3.4	5	12	0	0	.5	1.2
		Sept	1.86	.4	.7	1.8	3.3	4	7	0	0	.7	1.3
Miss:	Columbia	July	2.63	.7	1.9	1.4	3.7	12	32	16	42	.2	.5
		Aug	2.35	.9	2.1	1.8	4.1	12	28	14	33	.7	1.6
		Sept	1.74	.7	1.3	1.6	2.8	11	19	13	23	.6	1.0
Nebr:	Omaha	July	2.18	.7	1.4	1.3	2.9	6	13	12	26	1.2	2.6
		Aug	1.92	1.0	1.9	1.7	3.3	7	14	0	0	.9	1.7
		Sept	2.13	.8	1.7	1.4	3.0	5	11	0	0	.7	1.5
Nev:	Carson City	July	1.96	.7	1.4	1.6	3.1	4	8	13	25	.4	.8
		Aug	1.59	.7	1.2	1.7	2.8	3	5	0	0	.7	1.1
		Sept	1.46	.6	.9	1.5	2.2	5	7	11	16	.5	.7
N. Mex:	Albuquerque	July	NS										
		Aug	.92	.5	.5	1.9	1.7	8	7	0	0	.6	.6
		Sept	2.20	.5	1.2	1.6	3.5	5	10	0	0	.3	.7
Ore:	Portland	July	2.08	.4	.9	1.9	4.0	3	6	25	52	.3	.6
		Aug	2.47	.6	1.6	1.8	4.5	3	8	17	42	.4	1.0
		Sept	2.35	.6	1.3	1.6	3.6	3	8	20	47	.5	1.2
Utah:	Salt Lake City	July	1.90	.6	1.2	1.3	2.5	6	11	12	23	.4	.8
		Aug	1.90	.6	1.0	1.3	2.4	5	9	0	0	.3	.6
		Sept	1.67	.6	1.0	1.3	2.2	4	7	11	18	.4	.7
Institutional average		July	2.05	0.6	1.2	1.5	3.1	6	13	15	30	0.5	1.0
		Aug	1.84	0.7	1.3	1.6	3.0	7	12	7	13	0.6	1.0
		Sept	1.83	0.6	1.1	1.5	2.8	5	10	9	16	0.5	1.0

NS, no sample.

pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.82 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1967.

Strontium-90 dietary intake during this period averaged 8 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*4*). Cesium-137 intakes averaged 12 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg
Radium-226	0.1 pCi/kg

Data from eight axuiliary stations is included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December and Annual Summary 1967	July 1968
January–March 1968	October 1968
April–June 1968	January 1969

REFERENCES

(*1*) ANDERSON, E. C., D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(*3*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data 9:557–560 (October 1968).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

21

2. Strontium-90 in Tri-City Diets[1] February–June 1968

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium-90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (HASL). These estimates were made by using measurements of the strontium-90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department of Agriculture in their 1955 Household Diet Survey (1). A detailed description of the aims and methods of the HASL diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (2).

Starting in 1968, two changes have been made in the program. The first is the suspension of the collection and analyses of foods purchased in Chicago because previous experience had shown the levels of strontium-90 in the Chicago diet to be consistently between those of New York City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium-90 in Chicago at any time can be made from the analyses of foods purchased in New York and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture on their 1965 Household Diet Survey (3). The changes in the composition of the diet from 1955 to 1965 are not very great and the estimates of strontium-90 intake made using statistics from either diet survey are not too different. Estimates of the intakes of other nuclides, however, may be affected to a greater degree. The new estimates of consumption have therefore been used to calculate the intakes of calcium and strontium-90 for the first and second quarters of 1968 in New York City and San Francisco.

Results of the February–March 1968 samplings are presented in table 1; May–June 1968 in table 2. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet February–March 1968[a]

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City		San Francisco	
			February 1968		March 1968	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Dairy products	200	216.0	8.0	1,600	3.3	660
Fresh fruit	59	9.4	15.3	903	1.7	100
Fresh vegetables	48	18.7	9.9	475	2.7	130
Root vegetables	10	3.8	14.5	145	3.5	35
Potatoes	38	3.8	14.2	540	3.6	137
Macaroni	3	.6	3.4	10	2.0	6
Rice	3	1.1	2.1	6	1.5	5
Fruit juices	28	2.8	3.8	106	2.9	81
Canned vegetables	22	4.4	10.2	224	3.7	81
Canned fruit	11	.6	3.6	40	1.2	13
Dried beans	3	2.1	40.7	122	24.8	74
Flour	34	6.5	8.6	292	2.8	95
Bakery products	44	53.7	8.5	374	3.9	172
Whole grain products	11	10.3	12.4	136	7.0	77
Fresh fish	8	7.6	.6	5	.5	4
Shell fish	1	1.6	1.4	1	.7	1
Poultry	20	6.0	1.5	30	1.8	36
Meat	79	12.6	.7	55	.4	32
Eggs	15	8.7	3.1	47	1.4	21
Annual intake (pCi/yr)		370.0		5,111		1,760
Daily intake (pCi/day)				14.0		4.8

[a] January 1968 data not available.

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[1] Data from "Fallout Program Quarterly Summary Report, HASL-200." Available from the Clearinghouse for Federal Scientific & Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 2. Average dietary consumption and strontium-90 intake in Tri-City diet
May–June 1968

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City		San Francisco	
			May 1968		June 1968	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Dairy products	200	216.0	9.8	1,960	1.4	280
Fresh fruit	59	9.4	12.3	726	2.0	118
Fresh vegetables	48	18.7	20.1	965	4.6	221
Root vegetables	10	3.8	8.1	81	4.1	41
Potatoes	38	3.8	8.4	319	3.1	118
Macaroni	3	.6	3.4	10	3.9	12
Rice	3	1.1	1.3	4	1.0	3
Fruit juices	28	2.5	3.3	92	2.4	67
Canned vegetables	22	4.4	6.6	145	3.6	79
Canned fruit	11	.6	1.8	20	.9	10
Dried beans	3	2.1	20.3	61	6.7	20
Flour	34	6.5	7.3	248	3.6	122
Bakery products	44	32.7	5.3	233	3.5	154
Whole grain products	11	10.3	11.9	131	6.6	73
Fresh fish	8	7.6	.8	6	.3	3
Shellfish	1	1.6	1.5	2	.2	0
Poultry	20	6.0	2.5	50	3.6	72
Meat	79	12.6	.7	55	.3	24
Eggs	15	8.7	2.7	41	1.9	29
Annual intake (pCi/yr)		370.0		5,148		1,447
Daily intake (pCi/day)				14.1		4.0

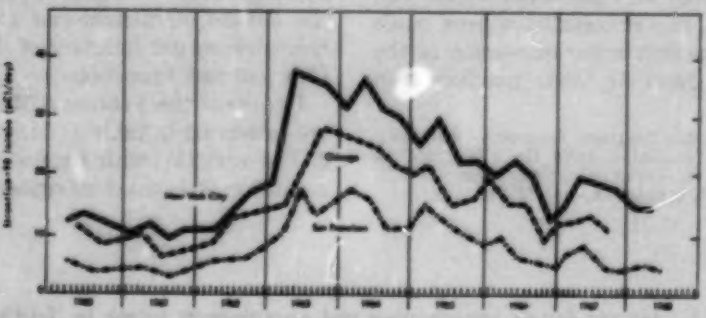

Figure 1. Daily intake of strontium-90 in Tri-City diet March 1960–June 1968

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1, (1955). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*3*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, spring 1965. A preliminary report, USDA, ARS 62–16 (August 1967).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	March 1968
April–December 1967	June 1968

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Last presented
California	July–December 1967	November 1968
Coast Guard	January–December 1967	February 1969
Florida	1967	February 1969
Minnesota	January–June 1968	February 1969
Washington	July 1966–June 1967	August 1968

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

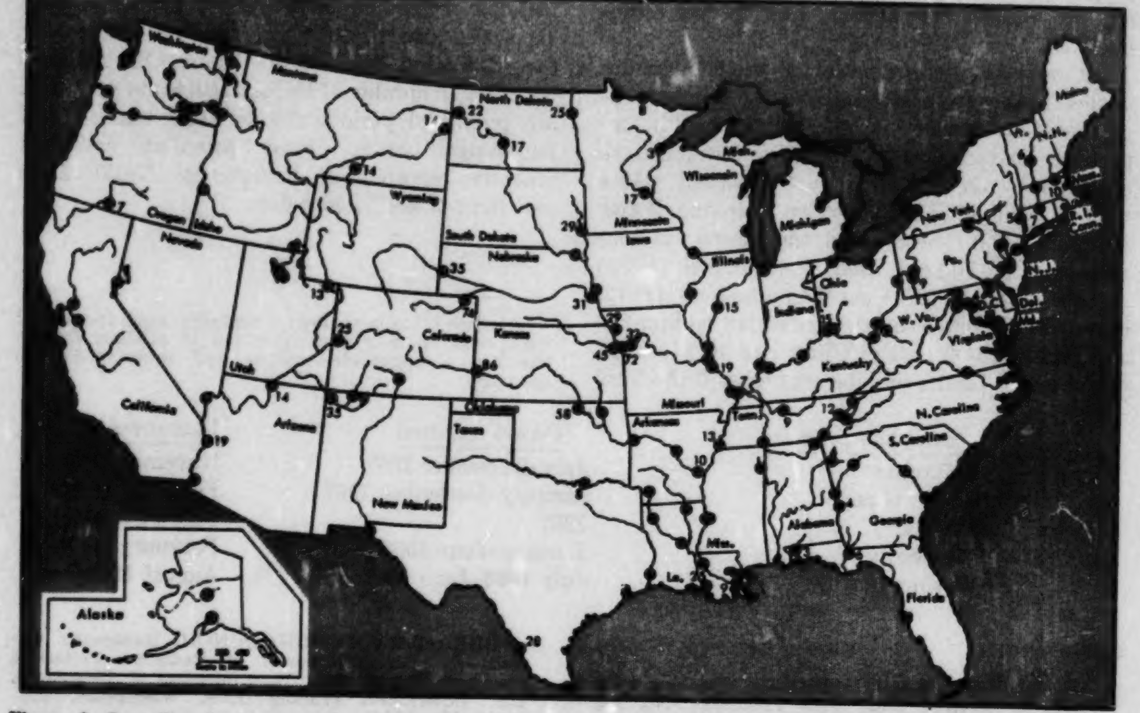
Gross Radioactivity in Surface Waters of the United States, October 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration, Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1-6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public


Washington
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North Dakota
Wyoming
South Dakota
Nebraska
Oregon
Idaho
Nevada
Utah
Colorado
Kansas
California
Arizona
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Oklahoma
Texas
Minnesota
Iowa
Wisconsin
Michigan
Illinois
Indiana
Ohio
Missouri
Arkansas
Kentucky
Tenn.
Miss.
Alabama
Georgia
La.
Florida
S.Carolina
N.Carolina
Virginia
W.Va.
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New York
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Del.
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Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, October 1968

Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During October 1968, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

Arkansas River; Coolidge, Kans.
Colorado River; Loma, Colo.
North Platte River; Henry, Nebr.
South Platte River: Julesburg, Colo.

During October 1968, no station showed a gross beta radioactivity in excess of 150 pCi/liter.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*2*) *Ibid.*, 1959 Edition.

(*3*) *Ibid.*, 1960 Edition.

(*4*) *Ibid.*, 1961 Edition.

(*5*) *Ibid.*, 1962 Edition.

(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1-15 (January 1968).

Table 1. Radioactivity in raw surface waters, October 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	0	1	1	1	8	9
Apalachicola River:						
Chattahoochee, Fla	0	0	0	3	3	6
Arkansas River:						
Coolidge, Kans	2	47	49	10	76	86
Ponca City, Okla	8	1	9	48	10	58
Pendleton Ferry, Ark	0	0	0	0	10	10
Atchafalaya River:						
Morgan City, La	4	1	5	16	9	25
Big Horn River:						
Hardin, Mont	0	1	1	1	13	14
Big Sioux River:						
Sioux Falls, S. Dak	1	1	2	5	24	29
Chattahoochee River:						
Columbus, Ga	0	0	0	0	4	4
Clinch River:						
Kingston, Tenn[a]	<1	<1	<1	2	10	12
Colorado River:						
Loma, Colo	2	15	17	10	15	25
Page, Ariz	0	4	4	<1	14	14
Parker Dam, Calif-Ariz	0	8	8	1	18	19
Connecticut River:						
Wilder, Vt	0	0	0	0	6	6
Enfield Dam, Conn	0	0	0	1	6	7
Coosa River:						
Rome, Ga	0	<1	<1	1	3	4
Cumberland River:						
Cheatham Lock, Tenn	0	0	0	0	9	9
Escambia River:						
Century, Fla	0	0	0	0	3	3
Great Lakes:						
Duluth, Minn	0	0	0	0	3	3
Green River:						
Dutch John, Utah	0	2	2	<1	13	13
Hudson River:						
Poughkeepsie, N.Y	0	0	0	1	4	5
Illinois River:						
Peoria, Ill	1	0	1	4	11	15
Kansas River:						
DeSoto, Kans	10	2	12	33	12	45
Klamath River:						
Keno, Ore	0	0	0	1	6	7
Merrimack River:						
Lowell, Mass	0	0	0	2	8	10
Mississippi River:						
St. Paul, Minn	0	3	3	1	16	17
E. St. Louis, Ill	1	1	2	8	11	19
W. Memphis, Ark	0	1	1	5	8	13
New Orleans, La	0	0	0	0	9	9
Missouri River:						
Williston, N. Dak	1	3	4	4	18	22
Bismarck, N. Dak	<1	3	3	3	15	18
St. Joseph, Mo	3	2	5	14	15	29
Missouri City, Mo	5	4	9	13	19	32
Monongahela River:						
Pittsburgh, Pa	0	0	0	0	9	9
North Platte River:						
Henry, Nebr	<1	16	16	5	30	35
Ohio River:						
Cincinnati, Ohio	0	1	1	2	13	15
Cairo, Ill	0	0	0	1	6	7
Platte River:						
Plattsmouth, Nebr	3	4	7	11	20	31
Potomac River:						
Washington, D.C	0	0	0	1	6	7
Rainy River:						
International Falls, Minn	0	0	0	0	8	8
Red River, North:						
Grand Forks, N. Dak	0	1	1	3	22	25
Red River, South:						
Denison, Tex	0	3	3	1	7	8
Rio Grande:						
Laredo, Tex	3	4	7	15	13	28
San Juan River:						
Shiprock, N. Mex	8	2	10	19	16	35
South Platte River:						
Julesburg, Colo	1	31	32	8	66	74
Yellowstone River:						
Sidney, Mont	0	0	0	2	12	14
Maximum	13	47	49	50	76	86
Minimum	0	0	0	0	3	3

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Radioactivity in New York Surface Water, January-June 1968

Division of General Engineering and
Radiological Health
State of New York Department of Health

In 1955, the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations. Water samples are obtained from 23 locations for gross beta-particle analysis (figure 1). Table 1 gives the number of samples, quarterly values, and type of sample. Larger samples are collected at selected locations for strontium-89 and strontium-90 analysis. A new analysis of tritium at selected locations is included in this report.

Analytical procedures

Strontium and other alkaline earths are precipitated as carbonates from a 500-ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulphate from a pH controlled EDTA solution. Calcium and yttrium remain in solution as EDTA complexes (*1–2*).

Strontium-90 is determined by yttrium-90 ingrowth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas-flow, proportional beta-particle counter. Strontium-89 is estimated by taking the difference between the total strontium and the strontium-90 radioactivity.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95-percent confidence level.

Discussion and results

Quarterly average, maximum, and minimum gross beta-particle concentrations in New York

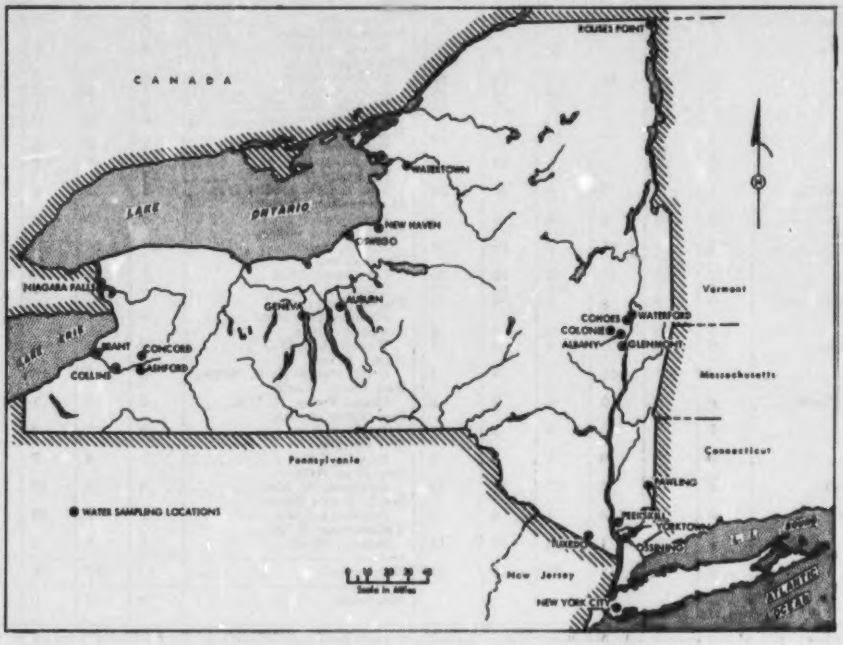
CANADA
LAKE ONTARIO
ROUSES POINT
WATERTOWN
NEW HAVEN
OSWEGO
NIAGARA FALLS
LAKE ERIE
BRANT
CONCORD
COLLINS
ASHFORD
GENEVA
AUBURN
COHOES
WATERFORD
COLONIE
ALBANY
GLENMONT
Vermont
Massachusetts
Connecticut
Pennsylvania
PAWLING
PEEKSKILL
YORKTOWN
OSSINING
TUXEDO
New Jersey
NEW YORK CITY
ATLANTIC OCEAN
N
● WATER SAMPLING LOCATIONS
0 10 20 30 40
Scale in Miles

Figure 1. New York water sampling locations

surface water for January–June 1968 are given in table 1. The Ashford station at Thomas Corners, Brant, Collins, and Concord stations are located downstream of the Nuclear Fuels Services reprocessing plant and show concentration levels well above natural background. An abnormally high concentration of gross beta radioactivity in one Hudson River sample at Sing Sing is attributed to intrusion of saline water.

The average, maximum, and minimum concentrations of strontium-89 and strontium-90 in New York water for January–June 1968 are given for four stations in table 2.

Tritium concentration values for January–June 1968 are given in table 3 for nine locations. Tritium, the radioactive isotope of hydrogen, a very low-energy beta emitter, is released to the water courses during the reprocessing of nuclear fuel. The tritium concentrations in Cattaraugus and Buttermilk Creeks showed the contribution of the Nuclear Fuels reprocessing plant.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–September 1967	January 1968
June–December 1967	October 1968

Table 1. Gross beta radioactivity in New York raw surface water, January–June 1968[a]

Location	Gross beta radioactivity (pCi/liter)							
	January-March 1968				April-June 1968			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	3	3	2	3	3	3	3
Ashford (Buttermilk Creek at Fox Valley Road)	3	10	18	5	3	8	18	4
(Buttermilk Creek at Thomas Corners)	13	1,478	3,262	583	7	1,406	3,923	182
(Cattaraugus Creek)[b]	3	8	12	5	3	3	4	2
Auburn (Owasco Lake)	1	3	3	3	1	4	4	4
Brant (Cattaraugus Creek)	5	89	90	31	12	28	47	15
Cohoes (Filtration Plant)	14	4	8	3	11	3	5	3
Collins (Cattaraugus Creek)	13	72	117	39	11	49	116	15
Colonie (Patroon Creek)	1	17	17	17	1	9	9	9
Concord (Cattaraugus Creek)	41	141	564	5	55	94	287	18
Geneva (Seneca Lake)	2	3	4	3	5	3	4	2
Glenmont (Hudson River)	13	5	8	3	13	4	6	3
New Haven (Lake Ontario)	1	7	7	7	3	4	4	4
New York City	7	4	5	3	4	3	5	2
Niagara Falls (West Branch, Niagara River)	3	3	5	1	2	5	6	4
Ossining (Indian Brook Reservoir)	2	5	5	5	4	5	7	4
(Sing Sing) (Hudson River)	8	19	46	2	15	15	117	9
Oswego	3	4	4	4	2	4	4	4
Pawling (Pond at United Nuclear)	3	42	88	7	3	4	4	3
Peekskill (Camp Field Water Supply)	3	3	4	2	5	4	6	5
(Hudson River)	12	16	52	3	15	6	18	2
Tuxedo (Indian Kill)	3	9	16	5	2	3	4	2
Watertown (Black River)	5	5	9	3	5	3	4	3
Yorktown (Croton Reservoir)	3	3	8	1	4	4	5	3

[a] Excluding tritium.
[b] This station is on the Nuclear Falls Services reprocessing plant site.

Table 2. Strontium-89 and strontium-90 concentration in New York surface waters, January–June 1968

Location	Strontium-89 (pCi/liter)								Strontium-90 (pCi/liter)							
	January-March 1968				April-June 1968				January-March 1968				April-June 1968			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Ashford (Buttermilk Creek at Fox Valley Road)	0	NA	NA	NA	0	NA	NA	NA	3	1	3	3	3	ND	ND	ND
(Buttermilk Creek at Thomas Corners)[a]	2	21	24	18	6	89	452	4	8	290	402	168	9	104	258	ND
Auburn (Owasco Lake)	0	NA	NA	NA		NA	NA	NA	2	<5	9	<5		NA	NA	NA
Concord (Springville Power Dam on Cattaraugus Creek)	0	NA	NA	NA	1	4	4	4	2	26	37	19	2	9	10	7

[a] This station is in the Nuclear Falls Services reprocessing plant site.
NA, no analysis.
ND, nondetectable.

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Table 3. Tritium concentration of New York surface waters, January–June 1968

Location	Concentration (pCi/liter)							
	January-March 1968				April-June 1968			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	1,836	2,380	1,480	2	1,025	1,360	ND
Ashford (Buttermilk Creek at Fox Valley Road)	3	<1,000	<1,000	<1,000	4	<1,000	1,880	1,010
(Buttermilk Creek at Thomas Corners)ᵃ	11	141,950	282,020	16,170	12	108,808	501,730	4,980
(Cattaraugus Creek)	3	<1,000	<1,000	<1,000	3	<1,000	1,590	<1,000
Brant (Cattaraugus Creek)	3	5,413	8,800	3,270	13	4,421	10,980	3,270
Cohoes (Filtration Plant)	13	1,204	2,190	<1,000	8	<1,000	1,630	<1,000
Collins (Cattaraugus Creek)	12	8,670	13,920	2,830	14	5,998	15,720	1,900
Concord (Springville Power Dam on Cattaraugus Creek)	40	14,596	27,180	1,980	54	10,700	30,580	12,240
New Haven (Lake Ontario)	1	2,050	2,020	2,030	3	<1,000	<1,000	<1,000

ᵃ This station is on the Nuclear Falls Services reprocessing plant site.
ND, nondetectable.

REFERENCES

(1) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium-90 in milk by ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(2) WELFORD, G., and D. SUTTON, a paper presented at the American Chemical Society meeting in New York City, September 1960.

Radiostrontium in Tap Water, January-June 1968

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (1).

Strontium-90 concentration and cesium-137/strontium-90 ratios in New York City tap water for January through July 1968 are presented in table 1. These results appear graphically in figure 1.

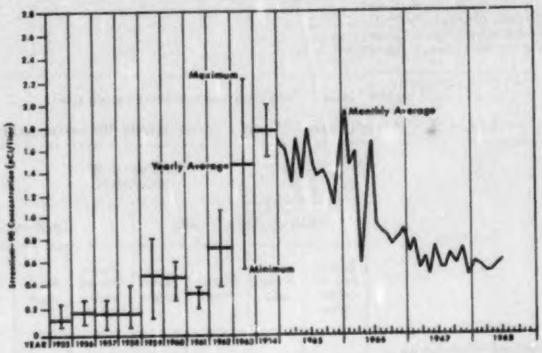

Figure 1. Strontium-90 concentrations in New York City tap water, 1955–June 1968

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the Interstate Carrier Drinking Water Standards (2).

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[1] Prepared from information appearing in "Fallout Program Quarterly Summary Report," HASL–204. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va., 22151.

Table 1. Radiostrontium in New York City tap water January–June 1968

Date	Strontium-90[a] (pCi/liter)	Cesium-137/ strontium-90
January	0.66	0.09
February	.56	.08
March	.50	.07
April	.51	.11
May	.55	.13
June	.60	.12

[a] Approximately 100 liters per sample.

REFERENCES

(1) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E-38-01-16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

(2) FEDERAL REGISTER RULES AND REGULATIONS. Title 42-Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–5. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1967	June 1968

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

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1. Radiation Alert Network, December 1968

Bureau of Radiological Health
U.S. Public Health Service

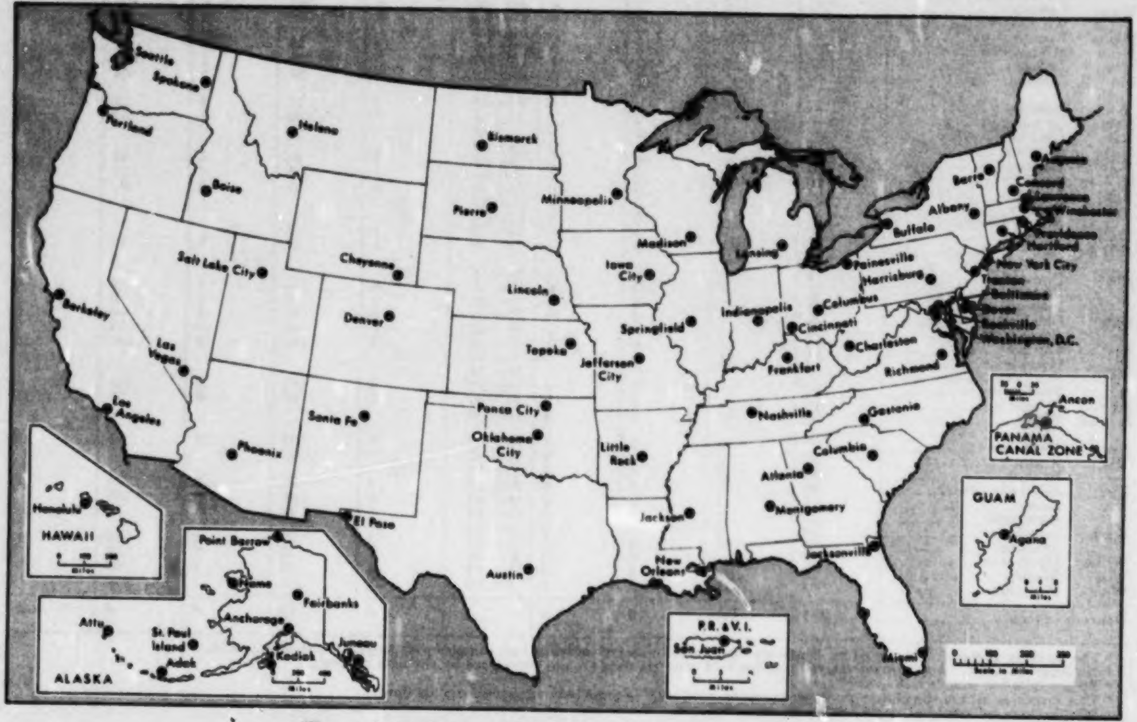
Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection when most of the radon daughter products have decayed, and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during December 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

In response to the execution of Project Schooner by the Atomic Energy Commission at the Nevada Test Site on December 8, 1968, 31 of the 73 RAN stations were requested to modify their routine sampling procedure and collect 12-hour air samples during the week of December 9–13. The operators of these stations were asked to perform a field estimate at either 5 or 12 hours after collection (depending on whether the sample was collected in the morning or at night, respectively) and then to send the filters to RAN headquarters in Rockville, Md. Significantly elevated levels of airborne radioactivity were observed at the following locations during this period.

Location	Maximum field estimate (pCi/m^3)
Idaho: Boise	457
Colo: Denver	173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Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
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Lincoln
Berkeley
Denver
Topeka
Las Vegas
Jefferson City
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
Little Rock
El Paso
Austin
Honolulu
HAWAII
Miles
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
ALASKA
Madison
Iowa City
Lansing
Springfield
Indianapolis
Columbus
Cincinnati
Charleston
Frankfort
Richmond
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
Buffalo
Painesville
Harrisburg
Albany
Barre
Augusta
Concord
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, December 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average [a]				Number of samples	Depth (mm)	Total deposition (nCi/m^2)
Ala:	Montgomery	26	5	0	1	Sept 68	7	90	7	90	12
Alaska:	Adak	31	2	1	2	Feb 69	(c)				
	Anchorage	11	0	0	0	Oct 68	1	4	(d)		
	Attu Island	31	0	0	0	Mar 69	(c)				
	Fairbanks	(b)				Nov 68	(c)				
	Juneau	21	0	0	0	Dec 68	11	69	11	69	0
	Kodiak	18	2	0	0	Jan 69	(c)				
	Nome	(b)				July 68	(c)				
	Point Barrow	15	1	0	0	Apr 69	(c)				
	St. Paul Island	30	1	1	1	Aug 68	(c)				
Ariz:	Phoenix	20	41	2	9	Dec 68	(c)				
Ark:	Little Rock	7	5	2	3	Oct 68	(c)				
Calif:	Berkeley	22	1	0	0	Jan 69	10	107	10	107	7
	Los Angeles	(b)				July 68	(c)				
C.Z:	Ancon	14	0	0	0	Jan 69	(c)				
Colo:	Denver	26	173	0	10	Jan 69	(c)				
Conn:	Hartford	21	0	0	0	Nov 68	6	101	6	101	0
Del:	Dover	21	1	0	0	Sept 68	(c)				
D.C:	Washington	2	0	0	0	Apr 69	(c)				
Fla:	Jacksonville	23	2	0	0	Oct 68	4	16	4	16	22
	Miami	22	1	0	0	Nov 68	(c)				
Ga:	Atlanta	24	2	1	1	Aug 68	4	142	4	142	112
Guam:	Agana	(b)				Sept 68	(c)				
Hawaii:	Honolulu	20	3	0	0	Mar 69	8	180	(d)		
Idaho:	Boise	27	457	0	19	Mar 69	11	41	11	41	21
Ill:	Springfield	26	3	0	1	Apr 69	1	35	0	0	(e)
Ind:	Indianapolis	26	4	0	1	Aug 68	8	109	8	109	123
Iowa:	Iowa City	23	5	0	1	Jan 69	2	39	1	35	0
Kans:	Topeka	28	5	0	1	Oct 68	4	43	4	43	1
Ky:	Frankfort	19	4	0	1	Apr 69	4	21	4	21	4
La:	New Orleans	23	1	0	0	Apr 69	8	238	(d)		
Maine:	Augusta	20	3	0	1	Dec 68	9	187	9	187	0
Md:	Baltimore	20	1	0	0	Nov 68	3	28	3	28	0
	Rockville	24	1	0	0	Mar 69	(c)				
Mass:	Lawrence	20	0	0	0	Sept 68	6	165	6	165	24
	Winchester	13	0	0	0	Feb 69	5	93	5	93	0
Mich:	Lansing	21	3	0	1	Mar 69	(c)				
Minn:	Minneapolis	21	1	0	0	Sept 68	8	34	8	34	1
Miss:	Jackson	20	2	0	1	Dec 68	5	229	5	229	164
Mo:	Jefferson City	26	1	0	0	Aug 68	5	64	5	64	0
Mont:	Helena	26	179	0	8	Feb 69	4	11	4	11	26
Nebr:	Lincoln	27	4	0	1	Aug 68	3	53	3	53	12
Nev:	Las Vegas	20	9	1	2	Nov 68	(c)				
N.H:	Concord	19	1	0	0	Apr 69	(c)				
N.J:	Trenton	26	1	0	0	Dec 68	5	48	5	48	28
N. Mex:	Santa Fe	21	3	0	1	Feb 69	4	26	4	26	2
N.Y:	Albany	19	1	0	0	Aug 68	8	91	8	91	79
	Buffalo	19	2	0	0	Jan 69	(c)				
	New York City	19	1	0	0	Feb 69	(c)				
N.C:	Gastonia	17	19	1	5	Jan 69	1	7	(d)		
N.Dak:	Bismarck	26	4	0	1	Apr 69	5	13	5	13	0
Ohio:	Cincinnati	9	2	0	1	Sept 68	(c)				
	Columbus	20	2	0	0	Dec 68	5	48	3	29	0
	Painesville	21	1	0	1	Nov 68	9	9	9	9	7
Okla:	Oklahoma City	22	3	0	0	Mar 69	3	40	3	40	0
	Ponca City	26	5	0	1	Nov 68	6	34	6	34	0
Ore:	Portland	20	5	0	0	Aug 68	18	140	18	140	18
Pa:	Harrisburg	18	1	0	0	Aug 68	(c)				
P.R:	San Juan	(b)				Dec 68	(c)				
R.I:	Providence	19	1	0	0	Mar 69	8	145	8	145	52
S.C:	Columbia	25	4	0	0	Feb 69	6	57	6	57	12
S. Dak:	Pierre	26	65	0	5	Dec 68	(c)				
Tenn:	Nashville	18	2	0	1	Mar 69	6	85	6	85	0
Tex:	Austin	17	8	0	2	Sept 68	3	68	(d)		
	El Paso	20	10	0	4	Apr 69	(c)				
Utah:	Salt Lake City	36	167	0	6	July 68	8	39	8	39	25
Vt:	Barre	16	1	0	0	Oct 68	8	106	8	106	0
Va:	Richmond	17	1	0	0	Oct 68	4	12	4	12	2
Wash:	Seattle	20	0	0	0	Oct 68	14	144	(d)		
	Spokane	18	44	0	2	Sept 68	5	25	5	25	82
W. Va:	Charleston	26	2	0	0	Feb 69	7	50	7	50	5
Wisc:	Madison	18	2	0	0	Oct 68	7	68	7	68	61
Wyo:	Cheyenne	28	171	1	6	Nov 68	1	2	1	2	11
Network summary		1,451	457	0	1		6	73	6	8	23

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

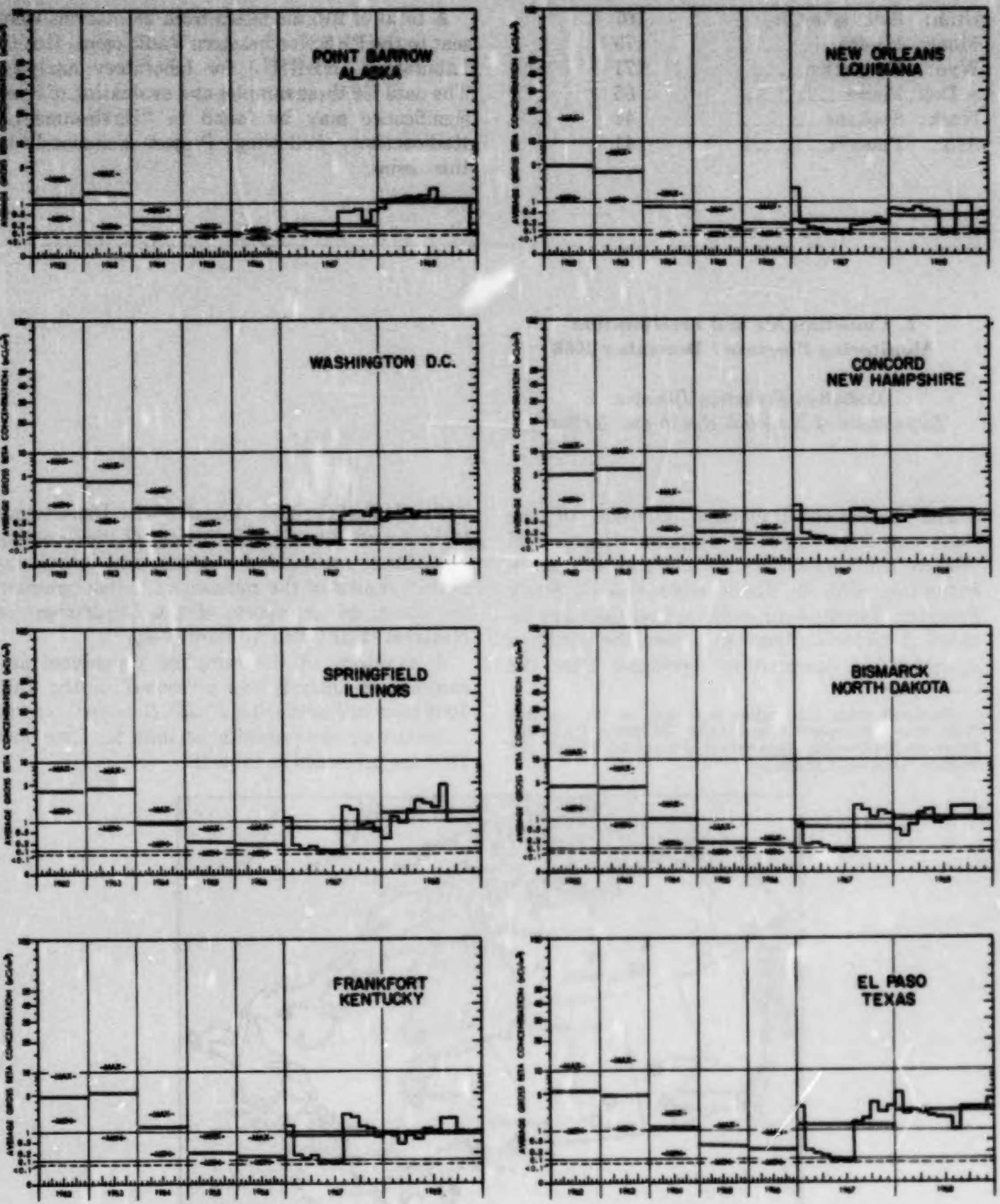

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1962–December 1968

Utah:	Salt Lake City	167
Mont:	Helena	179
Wyo:	Cheyenne	171
S. Dak:	Pierre	65
Wash:	Spokane	44
Ariz:	Phoenix	41

A total of 215 air filters from 28 stations were sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for laboratory analysis. The data for these samples and evaluation of their significance may be found in "Environmental Radioactivity Following Project Schooner" in this issue.

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2. Canadian Air and Precipitation Monitoring Program,[1] December 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the July 1968 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for December 1968 are presented in table 2.

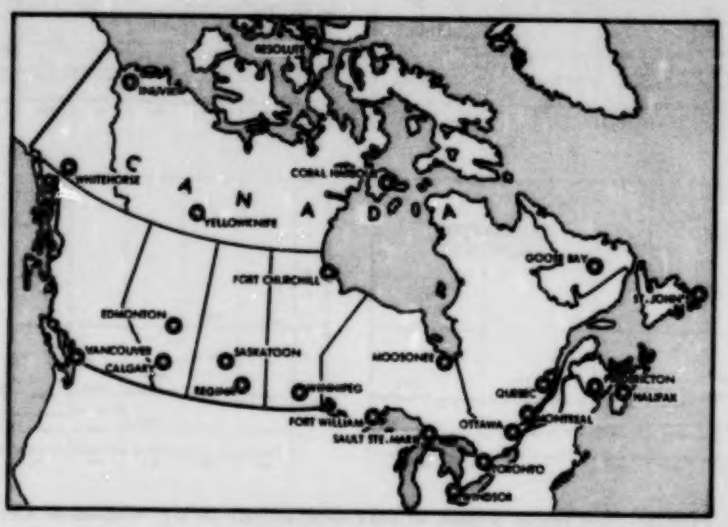
RESOLUTE
INUVIK
WHITEHORSE
C
A
N
A
D
A
YELLOWKNIFE
CORAL HARBOUR
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
OTTAWA
MONTREAL
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the January 1969 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, December 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.3	0.0	0.1	NA	NA
Coral Harbour	31	.1	.0	.1		
Edmonton	31	.1	.0	.1		
Ft. Churchill	30	.1	.0	.1		
Ft. William	31	1.5	.0	.1		
Fredericton	31	.5	.0	.1		
Goose Bay	29	.1	.0	.0		
Halifax	31	.6	.0	.1		
Inuvik	31	.1	.0	.1		
Montreal	31	1.1	.0	.1		
Moosonee	30	.1	.0	.0		
Ottawa	30	2.0	.0	.1		
Quebec	31	.9	.0	.1		
Regina	31	.3	.0	.1		
Resolute	29	.1	.0	.1		
St. John's, Nfld	31	.5	.0	.0		
Saskatoon	31	.4	.0	.1		
Sault Ste Marie	16	.1	.0	.1		
Toronto	30	.9	.0	.1		
Vancouver	29	.3	.0	.0		
Whitehorse	31	.1	.0	.0		
Windsor	31	.4	.0	.1		
Winnipeg	31	.2	.0	.1		
Yellowknife	31	.1	.0	.1		
Network summary	714	2.0	0.0	0.1		

NA, not available.

3. Mexican Air Monitoring Program July–August 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

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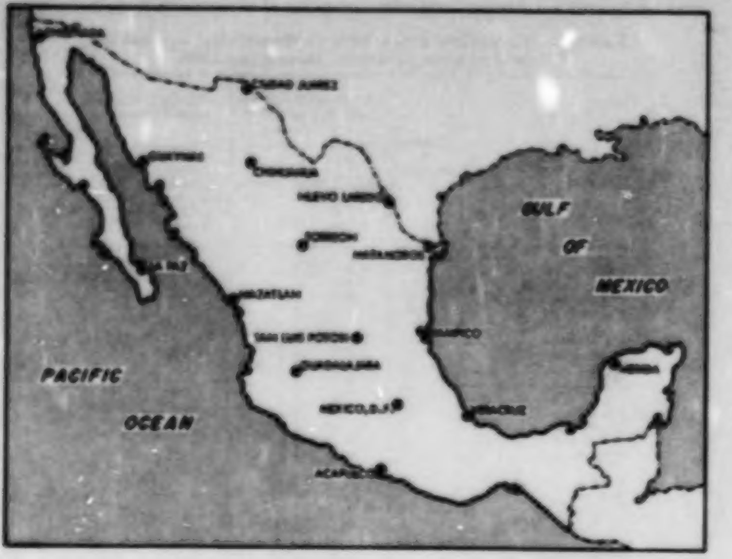
CIUDAD JUAREZ
GUAYMAS
CHIHUAHUA
NUEVO LAREDO
TORREON
MATAMOROS
LA PAZ
MAZATLAN
SAN LUIS POTOSI
TAMPICO
GUADALAJARA
MEXICO, D.F.
VERACRUZ
MERIDA
ACAPULCO
GULF OF MEXICO
PACIFIC OCEAN

Figure 4. Mexican air sampling stations

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of 5 samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta radioactivity in surface air during July and August 1968 are presented in tables 3 and 4, respectively.

Table 3. Mexican gross beta radioactivity of airborne particulates, July 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	11	0.1	0.1	0.1
Chihuahua	9	.2	.1	.1
Ciudad Juárez	4	.3	.1	.2
Ensenada	8	.3	.1	.2
Guadalajara	NS			
Guaymas	NS			
La Paz	2	.3	.1	.2
Matamoros	NS			
Mazatlán	8	.5	.2	.3
Mérida	NS			
México, D.F.	1	.2	.2	.2
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	4	.4	.3	.3
Torreón	8	.4	.2	.3
Veracruz	3	.3	.3	.3

NS, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates, August 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	4	0.3	0.2	0.2
Ciudad Juárez	3	.4	.3	.3
Ensenada	8	.6	.2	.5
Guadalajara	NS			
Guaymas	NS			
La Paz	3	.5	.2	.3
Matamoros	NS			
Mazatlán	NS			
Mérida	13	.5	.2	.4
México, D.F.	NS			
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	8	.2	.1	.2
Torreón	10	.1	.1	.1
Veracruz	15	.5	.1	.1

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program December 1968

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The December 1968 air monitoring results from the participating countries are given in table 5.

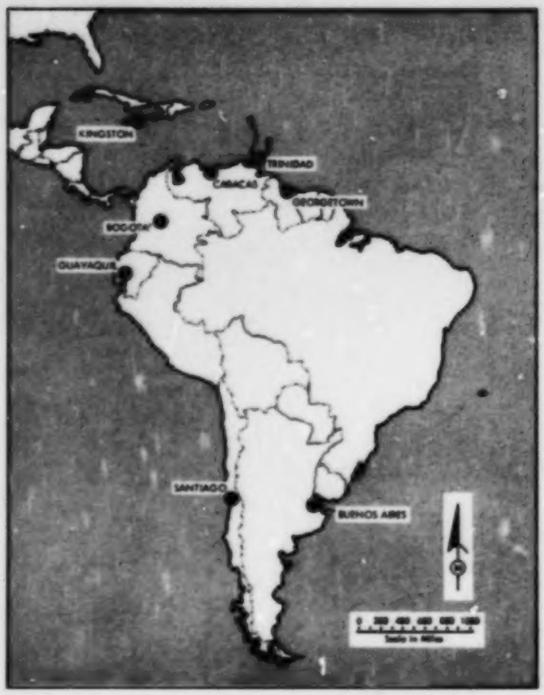

Figure 5. Pan American Air Sampling Program stations

Table 5. Summary of gross beta radioactivity in Pan American surface air, December 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average ᵃ
Argentina: Buenos Aires	17	0.43	0.08	0.24
Bolivia: La Paz	6	.75	.17	.27
Chile: Santiago	31	.40	.05	.20
Colombia: Bogota	11	.06	.01	.03
Ecuador: Guayaquil	21	.61	.17	.34
Guyana: Georgetown	15	.55	.01	.13
Jamaica: Kingston	19	.15	.03	.05
Peru: Lima	NS			
Venezuela: Caracas	9	.41	.03	.05
West Indies: Trinidad	20	.17	.01	.03
Pan American summary	149	0.75	0.01	0.16

ᵃ The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no samples received.

REFERENCES

(1) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. Bureau of Radiological Health, Office of Criteria and Standards, Rockville, Md. 20852 (Distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(4) MAR, P. G. Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(7) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Sequridad Radiológica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Radioactivity Following Project Schooner

Bureau of Radiological Health[1]
U.S. Public Health Service

On December 8, 1968, at 0800 P.s.t., the Atomic Energy Commission executed a nuclear cratering experiment as part of its Plowshare program to develop peaceful uses for nuclear explosives. The experiment, called Project Schooner, consisted of the detonation of a 35 kiloton (equivalent to 35,000 tons of TNT) minimum fission nuclear explosive at a depth of 350 feet underground at the Nevada Test Site. The purpose of this test was to provide information about cratering effects in hard rock. The detonation resulted in a crater about 800 feet wide and 250 feet deep and a release of radioactive debris into the atmosphere.

This report presents and evaluates the findings of the Public Health Service's two major nationwide environmental radioactivity surveillance networks following this event.

The Radiation Alert Network (RAN) consists of 73 stations located throughout the United States (figure 1) and provides an alert to increases in airborne radioactivity by the daily collection of 24-hour air samples and subsequent field estimation of gross beta radioactivity. Samples having unusual amounts of radioactivity are analyzed further at one of the Bureau of Radiological Health (BRH) regional laboratories. RAN results are published monthly in *Radiological Health Data and Reports*. A more complete description of RAN operational procedures was presented in the March 1968 issue.

In anticipation of the Schooner event, 31 of the 73 RAN stations were requested to modify their routine sampling procedure and collect 12-hour air samples during the period, Monday, December 9 through Friday, December 13. These stations were selected on the basis of predicted trajectories for the Schooner debris and are shown in figure 1. The operators of these stations were asked to perform a field estimate on these special samples at either 5 or 12 hours after collection (depending on whether the sample was collected in the morning or at night, respectively), and then to send the filters to RAN headquarters in Rockville, Md. Field estimates greater than 15 pCi/m^3 were to be reported to RAN headquarters by telephone.

The Pasteurized Milk Network (PMN) consists of 63 stations located throughout the United States (figure 2). Pasteurized milk samples are collected weekly from major milksheds and analyzed for radioactivity at the three BRH regional laboratories. The results are reported monthly in *Radiological Health Data and Reports*. A more complete description of the PMN may be found in the January 1968 issue.

In contrast to RAN procedures, increased sampling frequency is not initiated for the PMN prior to an event. Instead, preliminary post-shot RAN telephone alert reports are used as a guide to adjust PMN sampling frequency. Following the detonation of Schooner and in conjunction with preliminary telephone reports from various RAN stations, 12 of the 63 PMN stations

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[1] Special report prepared by the staff of the Radiological Surveillance Branch, Division of Environmental Radiation.

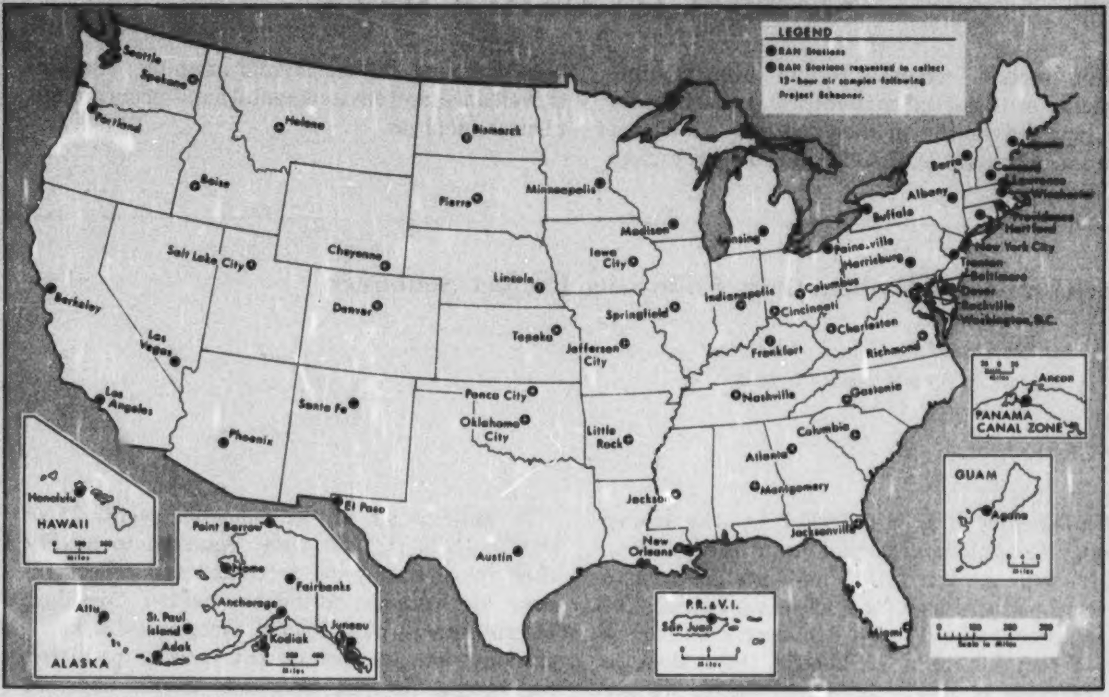
LEGEND
● RAN Stations
◉ RAN Stations requested to collect 12-hour air samples following Project Schooner.
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Salt Lake City
Cheyenne
Iowa City
Lincoln
Berkeley
Denver
Springfield
Indianapolis
Columbus
Cincinnati
Painesville
Harrisburg
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Las Vegas
Topeka
Jefferson City
Frankfort
Charleston
Richmond
Los Angeles
Ponca City
Oklahoma City
Santa Fe
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
ALASKA
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana
Miles
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

were requested to increase sampling frequency to twice per week. This frequency was maintained at these stations for 3 weeks following the event. The PMN stations which were requested to increase sampling frequency are shown in figure 2.

Results

The highest reported field estimate of airborne radioactivity following the Schooner event was 457 pCi/m³ for an air sample collected at Boise, Idaho from 2100 hours on December 9 to 0900 hours on December 10. Significantly elevated levels of airborne radioactivity were also observed at a number of other RAN stations during the week of December 9 to 13. Those stations with elevated field estimates are shown in table 1.

A total of 215 air filters from 28 stations were sent to the BRH Northeastern Radiological

Table 1. Field estimates of gross beta radioactivity (pCi/m³) for the week of December 9–13 for those RAN stations with significantly elevated levels

Station	Monday (12/9)		Tuesday (12/10)		Wednesday (12/11)		Thursday (12/12)		Friday (12/13)	
	AM[a]	PM[a]	AM	PM	AM	PM	AM	PM	AM	PM
Boise, Idaho	2	408	457	97	24	6	1	1	1	1
Denver, Colo.	8	4	160	173	43	10	4	1	1	[b]NR
Salt Lake City, Utah	3	[c]CS	167	17	9	0	0	0	0	0
Cheyenne, Wyo.	4	4	171	35	13	4	4	3	2	NR
Helena, Mont.	4	4	179	149	84	4	4	1	2	CS
Spokane, Wash.	0	CS	4	44	1	1	1	0	1	0
Pierre, S. Dak.	NR	4	7	44	65	26	8	3	2	NR
Phoenix, Ariz.	6	CS	14	CS	17	CS	41	CS	27	CS

[a] Unless otherwise indicated, these are 12-hour samples. AM samples generally represent collection from 2100 to 0000 and PM samples generally represent collection from 0900 to 2100.
[b] Not reported; an air sample was collected but no field estimate was made.
[c] Continuous sample.

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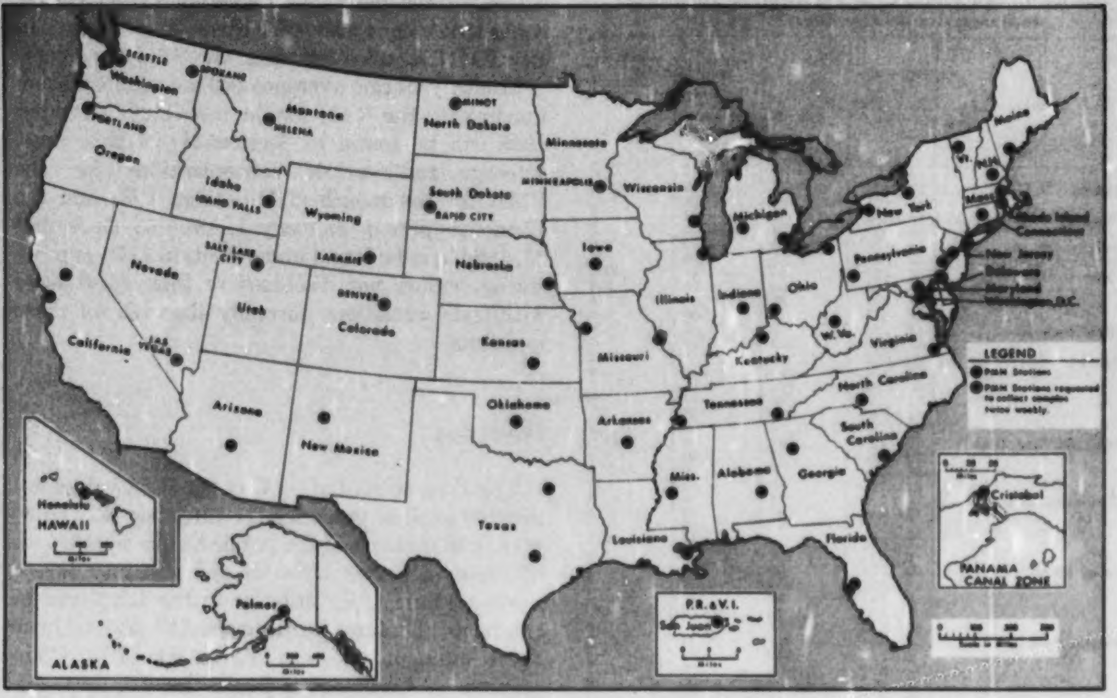
Seattle
Washington
Spokane
Portland
Oregon
Montana
Helena
Minot
North Dakota
Minnesota
Idaho
Idaho Falls
Wyoming
South Dakota
Rapid City
Minneapolis
Wisconsin
Michigan
New York
Maine
Vt.
N.H.
Mass.
Rhode Island
Connecticut
Salt Lake City
Laramie
Nebraska
Iowa
Pennsylvania
New Jersey
Delaware
Maryland
Washington, D.C.
Nevada
Utah
Denver
Colorado
Illinois
Indiana
Ohio
W. Va.
Virginia
California
Las Vegas
Kansas
Missouri
Kentucky
LEGEND
PMN Stations
PMN Stations requested to collect samples twice weekly.
Arizona
New Mexico
Oklahoma
Arkansas
Tennessee
North Carolina
South Carolina
Georgia
Alabama
Miss.
Texas
Louisiana
Florida
Honolulu
HAWAII
ALASKA
Palmer
P.R. & V.I.
San Juan
Cristobal
PANAMA CANAL ZONE

Figure 2. Pasteurized Milk Network sampling stations

Health Laboratory (NERHL) for more complete analysis. Each filter was counted for gross beta radioactivity immediately upon receipt at the laboratory. Table 2 gives the results for those samples which had a gross beta radioactivity greater than 0.5 pCi/m^3 (selected as a cutoff value for gamma analysis) at the time of counting. Forty-one air filters were over 0.5 pCi/m^3 and 28 of these were selected for gamma radioanalysis.

A total of 34 air filters were analyzed by gamma-ray spectroscopy including several filters chosen to provide background information. The results of these analyses are given in table 3. Each filter was counted for 50 minutes with a gamma-ray spectrometer incorporating a NaI (T1) crystal, and several were also counted for approximately 1,000 minutes with a germanium–lithium (GeLi) high resolution solid state spectrometer. The period between detonation and analysis for these samples varied from 6 to 18 days. Tungsten-187 was the predominant radionuclide identifiable in the gamma spectra of the samples analyzed at D+6 days. Quantitative data for this radionuclide were obtained from the solid state spectrometer output by hand spectrum stripping of the 0.686 MeV-peak (3.8 percent counting efficiency). Other radionuclides identified qualitatively are:

Beryllium-7
Potassium-40
Niobium-95
Zirconium-95
Ruthenium-103
Ruthenium-106
Iodine-131
Iodine-132
Cesium-134
Cesium-137
Barium-140
Lanthanum-140
Cerium-141
Tungsten-181

As the time between detonation and analysis increased, only these latter radionuclides were identifiable from the gamma spectra.

No detectable tungsten-187 concentrations (>50 pCi/liter) were found in any PMN samples following the Schooner event. Only one PMN

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Table 2. Air filters with a laboratory gross beta radioactivity greater than 0.5 pCi/m³

Station	Collection date (December 1968)		Field estimate (pCi/m³)	Laboratory gross beta radioactivity	
				Date (December 1968)	pCi/m³
Gastonia, N. C.	13	AM[a]	7	20	0.6
	13	PM[a]	[c] NR	19	[b] .6
Charleston, W. Va.	12	PM	1	20	.5
	13	AM	2	20	.7
Indianapolis, Ind.	13	PM	NR	20	[b] 1.2
Columbus, Ohio	13	AM	1	19	.7
Pierre, S. Dak.	10	PM	44	14	[b] 10.6
	11	AM	65	14	[b] 9.5
	11	PM	28	20	[b] 7.1
	12	AM	6	20	1.1
Little Rock, Ark.	11	PM	3	19	[b] .9
	13	AM	2	19	.7
Denver, Colo.	09	PM	4	14	[b] .8
	10	AM	100	14	[b] 3.8
	10	PM	173	14	[b] 78.7
	11	AM	48	14	[b] 17.8
	11	PM	10	20	[b] 3.6
	12	AM	4	20	1.2
Salt Lake City, Utah	10	AM[d]	167	20	[b] 37.0
	10	PM	17	20	[b] 9.8
	11	AM	9	14	[b] 7.8
	11	PM	0	19	1.1
Cheyenne, Wyo.	10	AM	171	19	[b] 80.3
	10	PM	25	19	[b] 23.3
	11	AM	13	19	[b] 4.9
	11	PM	4	20	1.9
	12	AM	4	20	1.6
Boise, Idaho	09	PM	408	14	[b] 191.8
	10	AM	457	14	[b] 315.2
	10	PM	97	20	[b] 65.4
	11	AM	24	20	[b] 12.7
	11	PM	6	20	1.0
Helena, Mont.	10	AM	179	14	[b] 69.4
	10	PM	140	20	[b] 73.6
	11	AM	84	20	[b] 41.7
	11	PM	4	20	.8
	12	AM	4	20	.7
Phoenix, Ariz.	12	AM[d]	41	26	[b] 13.3
	13	AM[d]	27	26	[b] 5.5
Spokane, Wash.	10	AM[d]	4	19	[b] 1.5
	10	PM	44	19	[b] 32.7

[a] Unless otherwise indicated, these are 12-hour samples. AM samples generally represent collection from 2100 to 0900 and PM samples represent collection from 0900 to 2100.
[b] Indicates samples which were selected for gamma analysis.
[c] Not reported; an air sample was collected but no field estimate was made.
[d] 24-hour samples.

sample was found to contain a detectable concentration (>10 pCi/liter) of iodine-131 during the month of December. This sample was collected from Portland, Maine on December 30, which had 13 pCi/liter of iodine-131. This value is within the statistical variation for detection of iodine-131 in milk.

There were three PMN stations which showed detectable concentrations (>10 pCi/liter) of iodine-131 or barium-140 following the Schooner event. They were Portland, Maine, which had 13 pCi/liter of iodine-131 on December 30, and Sacramento, Calif., and Omaha, Nebr., which had 16 and 18 pCi/liter of barium-140, respectively, on December 13. Significantly increased air concentrations were not observed in these States by the RAN. No detectable tungsten-187 concentrations (>50 pCi/liter) were found in any PMN samples following the Schooner event.

Monthly station averages and individual station maxima for the RAN for the month of December 1968 can be found in Section III of this issue. Average radionuclide concentrations for the PMN for the month of December 1968 and the 12-month period, January 1, 1968 to December 31, 1968, can be found under Section I. In general, station values not discussed in this report were within the variations normally observed for these locations.

Discussion

The Federal Radiation Council (FRC) does not provide explicit guidance for tungsten-187. However, as a measure of the public health significance of these increased airborne radioactivity levels, the maximum level observed in the RAN can be compared to a limit for tungsten-187 derived from the recommendations of the International Commission on Radiological Protection (ICRP).

A derived limit for tungsten-187 in air was calculated to be 10,000 pCi/m³; the most restrictive 168-hour occupational MPC for radiation workers was reduced using a factor of 1/10, in accordance with recommendations of FRC and ICRP, in order to arrive at a limit applicable to continuous inhalation over a 50-year period by an individual in the general population. The derived limit corresponds to a dose rate which would not exceed 0.5 rem/year, the FRC Radiation Protection Guide (RPG) for individuals in the general population.

The highest tungsten-187 concentration obtained from RAN samples was 917 pCi/m³ (corrected for decay to the end of sample collection) for a sample collected at Boise, Idaho on December 10. Had this concentration persisted indefinitely, the resultant dose would have been less than 10 percent of the RPG for individuals. Because the air concentrations remained elevated for only a few days at most, the resultant dose would actually be several orders of magnitude lower, or on the order of one-tenth of 1 percent of the RPG. Other locations with lower concentrations of tungsten in air would give correspondingly lower dose estimates. Based on these estimates, it

Table 3. Gamma spectroscopy results

Station	Collection date (December 1968)	Field estimate (pCi/m^3)	Laboratory gross beta radioactivity (pCi/m^3)	Gamma results	
				Fresh fission products and/or tungsten	^{187}W-quantitative (pCi/m^3) (at end of collection)
Gastonia, N.C.	13 PM	[a] NR	.6	No	
Indianapolis, Ind.	13 PM	NR	1.3	[b] Yes	
Pierre, S.Dak.	10 AM	7	.1	No	
	10 PM	44	10.6	Yes	48
	11 AM	66	9.5	Yes	19
	11 PM	20	7.1	Yes	
Austin, Tex.	10 AM	8	.2	Yes	
Little Rock, Ark.	11 PM	3	.9	[b] Yes	
Denver, Colo.	09 PM	4	.6	No	
	10 AM	160	[c] 3.8	Yes	120
	10 PM	173	76.7	Yes	175
	11 AM	43	17.8	Yes	27
	11 PM	10	3.6	Yes	
Salt Lake City, Utah	09 AM	3	.3	No	
	10 AM	167	37.6	Yes	
	10 PM	17	9.8	Yes	
	11 AM	9	7.8	Yes	36
Cheyenne, Wyo.	09 AM	4	.3	No	
	10 AM	171	80.3	Yes	
	10 PM	35	23.3	Yes	
	11 AM	13	4.9	Yes	
Boise, Idaho	09 AM	2	.1	No	
	09 PM	408	191.8	Yes	937
	10 AM	457	315.2	Yes	917
	10 PM	97	65.4	Yes	
	11 AM	24	12.7	Yes	
Helena, Mont.	09 PM	4	.1	No	
	10 AM	179	69.4	Yes	166
	10 PM	149	76.6	Yes	
	11 AM	84	41.7	Yes	
Phoenix, Ariz.	12 AM	41	13.3	Yes	
	13 AM	27	5.5	Yes	
Spokane, Wash.	10 AM	4	1.5	Yes	
	10 PM	44	32.7	Yes	

[a] Not reported; an air sample collected but no field estimate was made.
[b] Tentative identification-based primarily on the presence of the x-ray peak.
[c] Questionable value.

is concluded that no public health problem resulted from the Schooner event.

Summary

Significantly elevated levels of airborne radioactivity were observed at several RAN stations following the Schooner event; some of the maximum values were the highest that have been observed at these locations since 1962. These levels were of short duration, with all affected locations returning to normal background activities within a few days. The composition of the radioactivity in the samples was different from that observed in the early 1960's. The predominant radionuclide was tungsten-187, which decays rapidly with a half-life of 24 hours. Only small amounts of iodine-131 and other fresh fission products were observed in RAN air samples following Schooner. No tungsten-187 was detected in samples collected as a part of the PMN and only one milk sample had a detectable concentration of iodine-131. Based on the data obtained from these two networks, it is concluded that no public health hazard resulted from Project Schooner.

Strontium-90 in Human Bone, January-March 1968[1]

Bureau of Radiological Health
Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium-90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority

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[1] Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, January-March 1968

Bone region and State		Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:	Mass	V	00	M	079.4 ±[c] 14.0	35.6	2.23
	N. Y	V	00	M	102.0 ± 16.0	33.1	3.08
	Mass	V	03	M	104.0 ± 8.0	35.1	2.96
		V	05	M	107.0 ± 10.0	23.8	4.49
		V	06	M	101.0 ± 9.5	34.6	2.91
	N. J	V	06	F	286.0 ± 20.0	90.4	3.18
	Pa	V	07	M	53.5 ± 8.1	20.3	2.63
	Mass	V	08	M	47.6 ± 8.0	31.7	1.50
		V	08	M	172.0 ± 12.0	36.7	4.68
	N. Y	V	08	F	58.6 ± 6.3	34.2	1.71
	Mass	V	09	M	110.0 ± 11.0	30.1	3.65
		V	10	M	76.8 ± 6.6	31.3	2.45
		V	12	M	79.9 ± 7.8	36.5	2.18
	Vt	V	15	M	141.0 ± 12.0	46.7	3.01
	N. Y	V	15	M	75.3 ± 8.7	30.6	2.46
	Mass	V	16	F	164.0 ± 14.0	52.0	3.15
	N. Y	V	17	M	141.0 ± 12.0	51.1	2.75
		V	17	M	185.0 ± 47.0	66.3	2.79
		V	17	M	119.0 ± 12.0	50.5	2.35
		V	19	M	46.5 ± 6.2	35.9	1.29
	Mass	V	20	M	99.7 ± 8.3	44.0	2.26
	N. Y	V	20	M	61.5 ± 6.9	29.6	2.07
		V	25	M	121.0 ± 10.0	52.8	2.29
Southeast:	S. C	V	00	M	152.0 ± 20.0	29.4	5.17
		V	00	M	92.8 ± 12.0	19.7	4.71
		V	01	F	77.0 ± 17.0	26.4	2.91
		V	01	F	161.0 ± 18.0	29.4	5.47
	N. C	V	02	M	143.0 ± 15.0	27.0	5.29
	S. C	V	02	M	100.0 ± 10.0	24.4	4.09
		V	02	F	75.4 ± 9.7	26.2	2.87
	Md	V	07	F	76.7 ± 8.7	28.6	2.68
		V	07	M	85.9 ± 11.0	30.7	2.79
	N. C	V	07	F	114.0 ± 13.0	24.7	4.61
	Ga	V	08	F	144.0 ± 17.0	38.9	3.70
	Ala	V	11	M	60.8 ± 8.5	30.3	2.00
	S. C	V	12	F	80.4 ± 8.9	27.2	2.95
	Md	V	14	M	124.0 ± 13.0	47.4	2.61
	N. C	V	14	F	68.4 ± 8.9	23.4	2.92
	Va	V	14	M	65.3 ± 8.2	23.7	2.75
	Md	V	15	M	180.0 ± 14.0	63.2	2.84
	N. C	V	15	F	144.0 ± 10.0	43.0	3.34
	Md	V	16	M	130.0 ± 13.0	46.9	2.77
		V	17	M	150.0 ± 13.0	55.7	2.69
		V	17	F	93.9 ± 8.6	46.8	2.00
		V	17	M	161.0 ± 14.0	61.4	2.62
		V	17	M	163.0 ± 15.0	55.5	2.93
	N. C	V	17	F	96.9 ± 8.3	36.3	2.66
	Md	V	18	M	108.0 ± 11.0	47.0	2.29
		V	18	M	183.0 ± 14.0	55.0	3.32
	N. C	V	18	F	92.0 ± 13.0	34.5	2.66
		V	18	M	280.0 ± 16.0	51.4	5.44
	Md	V	19	M	96.6 ± 11.0	53.9	1.79
		V	19	M	122.0 ± 13.0	63.4	1.92
		V	19	M	62.1 ± 9.4	51.1	1.21
		V	20	M	85.2 ± 10.0	54.1	1.57
		V	20	M	111.0 ± 9.5	45.9	2.41
		V	20	M	103.0 ± 7.8	44.1	2.33
		V	21	M	68.5 ± 8.4	48.4	1.41
	Ga	V	21	M	261.0 ± 18.0	56.6	4.61
	Md	V	22	M	106.0 ± 10.0	61.7	1.71
	D. C	V	22	M	99.7 ± 9.6	58.0	1.71
	Md	V	22	M	104.0 ± 11.0	55.3	1.88
		V	22	M	110.0 ± 10.0	50.7	2.16
		V	22	M	104.0 ± 10.0	59.3	1.75
	S. C	V	22	F	160.0 ± 17.0	58.3	2.80
	Md	V	23	M	156.0 ± 9.6	50.3	3.10
		V	23	M	83.1 ± 10.0	49.0	1.69
	N. C	V	23	F	227.0 ± 17.0	45.7	4.96
		V	23	M	87.0 ± 10.0	32.1	2.71
	S. C	V	23	F	57.0 ± 8.7	48.9	1.16
	Md	V	24	M	151.0 ± 15.0	78.2	1.93
		V	24	M	115.0 ± 13.0	69.2	1.66
		V	24	M	82.7 ± 9.0	44.2	1.87
	S. C	V	25	F	74.3 ± 7.1	40.7	1.82
Central:	Wisc	V	00	F	109.0 ± 15.0	40.1	2.71
		V	00	F	54.0 ± 12.0	27.9	1.93
		V	00	F	92.5 ± 16.0	40.5	2.28
	Ohio	V	01	F	98.4 ± 15.0	31.0	3.17
	Wisc	V	01	M	52.3 ± 10.0	17.8	2.93
		V	01	M	52.1 ± 17.0	34.4	1.51
	Ohio	V	01	M	96.2 ± 13.0	25.3	3.80
	Wisc	V	05	M	50.2 ± 7.5	25.9	1.93
		V	06	M	128.0 ± 12.0	28.0	4.57
		V	07	M	64.3 ± 6.8	34.8	1.84
	Ohio	V	07	M	191.0 ± 14.0	50.7	3.76
	Iowa	V	10	F	58.7 ± 7.2	33.0	1.77
	Wisc	V	15	M	162.0 ± 12.0	53.2	3.04
	Ohio	V	17	F	127.0 ± 11.0	50.6	2.50

See footnotes at end of table.

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Table 1. Strontium-90 in human bone, January–March 1968—Continued

Bone region and State		Bone type [a]	Age [b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Central:	Ohio	V	17	M	164.0 ± 13.0	73.3	2.23
	Minn.	V	20	M	70.7 ± 9.9	44.0	1.60
	Ohio	V	20	M	90.4 ± 8.7	58.6	1.54
Delta:	Tenn.	V	11	M	76.2 ± 6.9	35.0	2.17
	La.	V, R	14	M	68.5 ± 9.1	38.0	1.80
		V, R	18	M	95.2 ± 12.0	67.8	1.40
		V, R	22	M	151.0 ± 14.0	64.5	2.34
	Tenn.	V	25	F	68.0 ± 8.2	41.6	1.63
Northwest:	Ore.	V	04	M	71.3 ± 6.6	29.5	2.41
		V	10	F	65.5 ± 6.6	38.0	1.72
		V	12	M	101.0 ± 11.0	41.6	2.42
	Wash.	V	13	F	94.4 ± 9.2	36.3	2.60
	Ore.	V	15	M	109.0 ± 9.4	39.1	2.78
		V	15	F	126.0 ± 9.8	55.1	2.28
		V	16	M	114.0 ± 10.0	47.9	2.37
		V	16	F	69.8 ± 6.9	38.6	1.80
		V	17	M	84.8 ± 10.0	51.9	1.63
		V	17	M	123.0 ± 12.0	48.7	2.52
	Alaska	R	18	M	866.0 ± 78.0	29.0	6.71
	Ore.	V	19	M	86.0 ± 9.5	50.0	1.72
		V	19	F	83.8 ± 8.1	50.8	1.64
		V	22	M	66.1 ± 10.0	50.1	1.29
		V	22	M	63.3 ± 7.4	54.9	1.15
	Alaska	R	23	M	973.0 ± 70.0	45.0	6.71
		V	24	M	63.0 ± 10.0	55.5	1.13
Southwest:	Tex.	V	08	F	59.4 ± 10.0	29.9	1.98
	Colo.	V, R	10	M	130.0 ± 13.0	54.3	2.39
		V	11	M	46.8 ± 8.9	35.0	1.33
	Tex.	V	13	M	112.0 ± 12.0	43.3	2.58
	Colo.	V	15	M	71.1 ± 8.6	45.5	1.56
		V	16	F	92.3 ± 16.0	51.8	1.78
		V	18	M	76.4 ± 11.0	53.6	1.42
		V	18	M	125.0 ± 11.0	52.1	2.39
		V	18	M	110.0 ± 10.0	41.8	2.63
		V	19	M	78.5 ± 11.0	59.0	1.33
		V	21	F	51.7 ± 8.6	52.8	.97
	Calif.	V	24	M	103.0 ± 11.0	52.3	1.96

[a] Type of bone: vertebrae, V; rib, R.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at Northeastern Radiological Health Laboratory of the Bureau of Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 radioactivity. For the purpose of maintaining analytical reproducibility, blind duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium-90) are analyzed periodically and cross-check analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium-90 in individual bones from persons dying during the first quarter (January–March) of 1968 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	June 1968
April–June 1967	September 1968
July–September 1967	October 1968
October–December 1967	February 1969

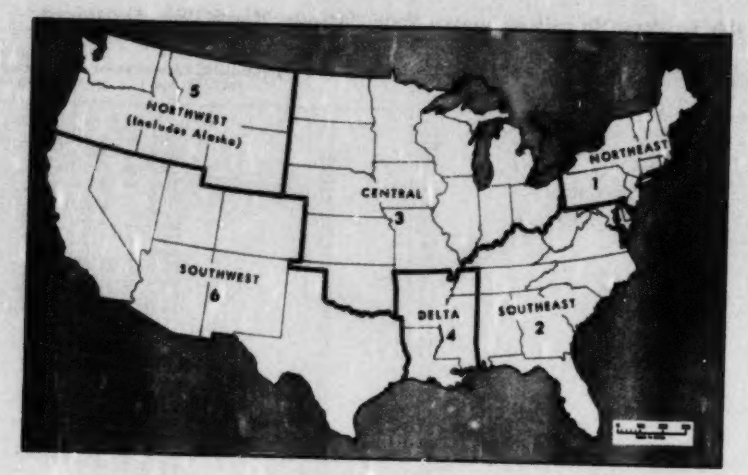

Figure 1. Geographical regions for human bone sampling

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Iodine-131 in Bovine Thyroid, October-December 1968

Bureau of Radiological Health
Public Health Service

The Bureau of Radiological Health (formerly the National Center for Radiological Health) established a bovine thyroid network in October 1964 (*1*). Specimens are collected by the Livestock Slaughter Inspection Division, U.S. Department of Agriculture, and are analyzed by gamma-ray

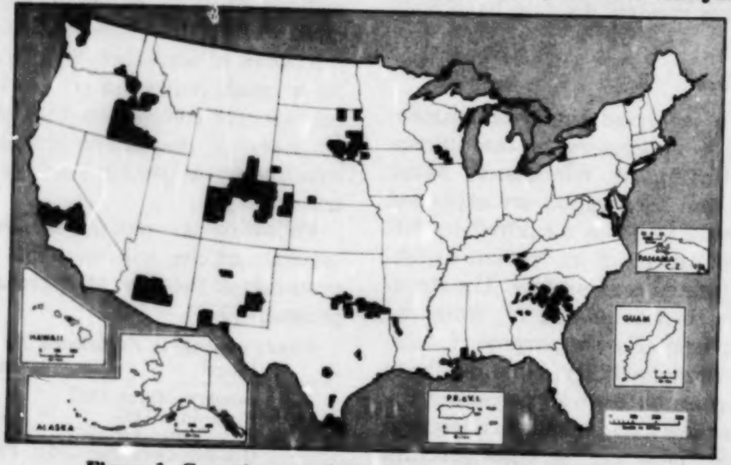

Figure 1. Counties sampled in bovine thyroid network, October–December 1968

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Table 1. Iodine-131 in bovine thyroids, October–December 1968

State	Date of slaughter	County	Number of samples	pCi iodine-131/g thyroid[a]		
				Average or concentration	Minimum	Maximum
Arizona	10/4–11/27[b]	Maricopa	11	4	0	31
	12/19	Pinal	1	0		
California	10/8–12/19[b]	Fresno (3)[c]	20	0		
		Monterey (10)				
		San Benito (5)				
		Tulare (2)				
Colorado	10/15–12/10[b]	Adams (4)[c]	5	0		
		Boulder (1)				
	11/1–12/19[b]	Delta	16	2	0	6
	10/22–12/11[b]	El Paso	5	0		
	10/10–10/28	Elbert	2	11	0	23
	10/15–12/10[b]	Garfield	26	3	0	13
	10/24–12/18[b]	Grand (1)[c]	11	0		
		Jackson (1)				
		Kit Carson (3)				
		Larimer (6)				
	10/4–12/4[b]	Mesa	37	5	0	31
	11/7	Montrose	10	[d] 0		
	10/22	Morgan	1	0		
	11/29	Rio Blanco	10	1	0	7
	10/10	Routt	1	6		
	10/10–12/18[b]	Weld	19	0	0	6
	10/29	Yuma	1	4		
Georgia	10/10–12/17[b]	Bibb (7)[c]	27	[d] 0		
		Bulloch (2)				
		Burke (4)				
		Candler (3)				
		Clarke (6)				
		Columbia (3)				
		Emanuel (2)				
	10/10	Evans	2	5	2	7
	10/10–11/20	Franklin	2	[d] 0		
	10/3–11/27[b]	Fulton	6	7	5	15
	10/16–12/17[b]	Greene (5)[c]	6	[d] 0		
		Jenkins (1)				
	10/9–11/27[b]	McDuffie	21	3	0	11
	10/16–12/17[b]	Muscogee (5)[c]	14	0		
		Screven (8)				
		Upson (1)				
	10/3–11/6[b]	Walton	7	4	0	10
	10/23–12/12[b]	Warren	4	3	0	6
	10/23–12/17[b]	Wilkes	8	0		
Idaho	10/4–12/9[b]	Canyon (3)[c]	25	[d] 0		
		Owyhee (7)				
		Twin Falls (2)				
		Valley (6)				
		Washington (7)				
Iowa	10/14	Sioux	10	2	0	7
Louisiana	11/6–12/9	Bossier	2	0		
	10/14	Red River	1	9		
Minnesota	11/5	Rock	4	0		
Mississippi	10/1–10/16[b]	George (2)[c]	4	[d] 0		
		(2)				
		Jackson	14	1	0	7
Nebraska	11/4–11/19[b]	Red Willow (1)[c]	2	0		
		Scotts Bluff (1)				
New Mexico	11/4–12/2[b]	Bernalillo (4)[c]	14	0		
		Chaves (10)				
	10/10	Luna	1	11		
New York	10/7–12/12[b]	Chautauqua	59	0		
Oklahoma	10/22–12/6[b]	Bryan (1)[c]	3	[d] 0		
		Carter (2)				
	11/5		1	8		
	10/23–12/5	Jefferson	2	0		
Oregon	12/25–12/3[b]	Malheur (3)[c]	7	0		
		Wallowa (4)				
South Carolina	10/16–12/12[b]	Abbeville (2)[c]	11	[d] 0		
		Aiken (2)				
		Barnwell (6)				
		Colleton (1)				
	11/6–12/17[b]	Greenwood	4	2	0	9

See footnotes at end of table.

Table 1. Iodine-131 in bovine thyroids, October–December 1968—Continued

State	Date of slaughter	County	Number of samples	pCi iodine-131/g thyroid [a]		
				Average or concentration	Minimum	Maximum
South Carolina	10/16–12/17 [b]	Lexington (1) [c] McCormick (2) Orangeburg (3) Richland (2)	8	[d] 0		
South Dakota	10/2–12/16 [b]	Aurora (10) [c] Brookings (6) Brown (3) Brule (20) Charles Mix (1) Davidson (11) Douglas (2) Hutchinson (7) Kingsbury (5) Lake (1) Mc Cook (11) Minnehaha (3) Moody (1) Roberts (6) Turner (4) Yankton	91	[d] 0		
Tennessee	10/8	Anderson	4	6	2	9
	10/1–12/3 [b]	Blount	1	7		
	10/1–12/3	Clairborne	19	2	0	6
	10/1–12/3 [b]	Fentress (1)	2	[d] 0		
		Knox (11)	12	[d] 0		
	10/1–12/3 [b]	Seiver	4	4	0	17
Texas	11/25–12/17	Bexar (3) [c] Bowie (1)	4	[d] 0		
	10/4	Brazos	1	8		
	12/4	Cameron	3	0		
	10/9	Clay	1	13		
	10/7	Cooke	1	6		
	10/28–11/26	Denton	2	[d] 0		
	10/15–12/6 [b]	El Paso	4	4	0	9
	10/9	Fannin	1	6		
	10/31–11/13	Hidalgo (2) [c] Hopkins (1)	3	[d] 0		
	10/3		3	7	7	8
	10/10–12/12 [b]	Jim Wells (7) [c] Lamar (1) Red River (1) Titus (1) Willacy (7)	17	[d] 0		
Vermont	10/7–11/6 [b]	Franklin	30	[d] 0		
Washington	10/10–12/12 [b]	Walla Walla	15	[d] 0		
Wisconsin	10/9–11/22 [b]	Dane	14	1	0	8
	10/8	Rock	6	3	0	6
	11/8	Sauk	2	0		
Wyoming	10/17	Albany	1	0		

[a] All samples <1 pCi/g are reported as 0, since at these levels of radioactivity, the 2-standard deviation error is 1 pCi iodine-131/g thyroid.

[b] Samples were not collected on all dates during this period, but the interval includes several sampling dates.

[c] Numbers in parentheses represent the number of samples collected from that country during the interval indicated. These may have been collected over several dates or on only one date.

[d] The results for this period were for the most part not detectable. Some randomly scattered positive results were obtained; but these represented barely detectable amounts of iodine-131 in the bovine thyroid (2 to 5 pCi/g).

Dash indicates no data received.

spectroscopy for iodine-131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants, and nuclear test sites. Details of sampling and analyses have been published earlier (*1*).

The results for October through December 1968 appear in table 1 and are listed chronologically within each State. Moderate elevations in radioactivity were found in 15 States during this period. The two most active samples analyzed were collected in Maricopa County, Arizona and Mesa County, Colorado on October 4. They contained 31 pCi iodine-131/g thyroid.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1968	November 1968
July–September 1968	February 1969

REFERENCE

(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine-131 in bovine thyroids, October–December 1964. Radiol Health Data 6:569–571 (October 1965).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summary of the environmental radioactivity data follow for the Feed Materials Production Center.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Feed Materials Production Center[2]
January–June 1968

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. In order to determine what concentrations reach the area surrounding the project, an environmental survey program has been established which consists of water, soil, and air sampling of the environs and performing those analyses on the samples that are indicative of material released from the plants.

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 2. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling

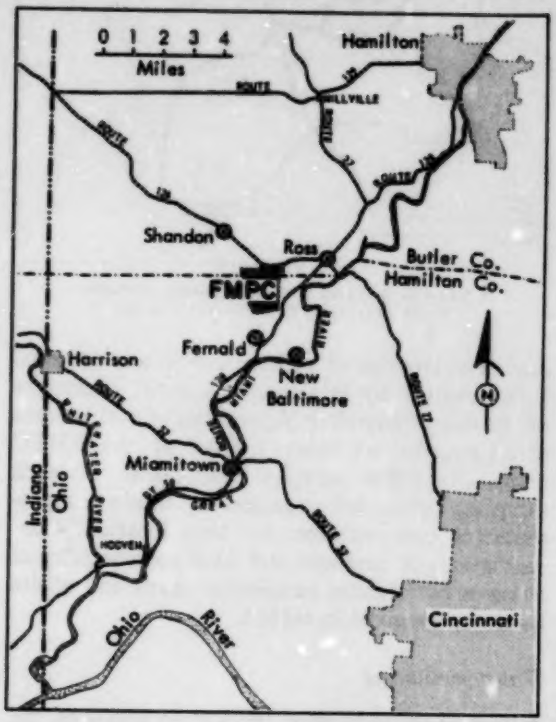

Figure 1. Area map of Feed Materials Production Center

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[2] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the First Half of 1968" (NLCO-1023).

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Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, January–June 1968

Location	Number of samples	Uranium concentration (pCi/m³)[a]			Total radioactivity (pCi/m³)[b]		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest	27	0.7	<0.1	0.2	1.3	<0.1	0.5
Northwest	27	.2	< .1	< .1	.4	< .1	.3
Northeast	27	.3	< .1	.1	.7	.1	.4
Southeast	27	.3	< .1	.1	1.1	< .1	.4
All onsite samples	108	.7		.1	1.3		.4
Offsite:							
0–2 miles from FMPC	36	.5	< .1	.2	1.4	0.2	.7
2–4 miles from FMPC	39	.1	< .1	< .1	.9	< .1	.4
4–8 miles from FMPC	22	.2	< .1	< .1	.6	< .1	.3
8–12 miles from FMPC	16	< .1	< .1	< .1	.5	< .1	.2
All offsite samples	113	0.5		< .1	1.4		.4

[a] AEC radiation protection standard—2 pCi/m³.
[b] AEC radiation protection standard—100 pCi/m³.

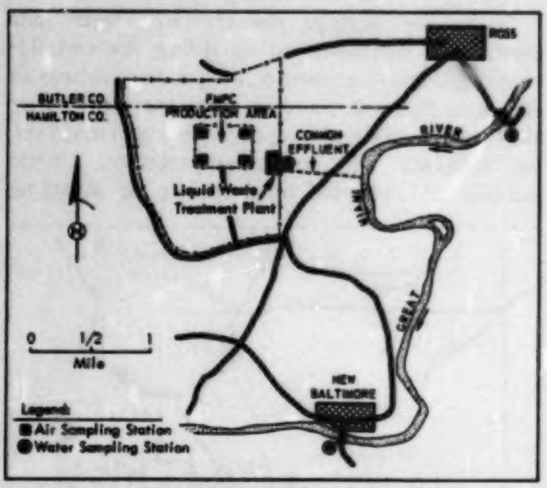

Figure 2. Air and water sampling stations Feed Materials Production Center

unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 1.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants are collected at a general sump for equalization and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The flow, which is decanted to the clear well portion of the pit, is virtually free of solids and radioactivity. The effluent from the sump and clear well are combined with wastewater from the FMPC water treatment plant, sanitary sewage treatment plant, and storms weerage system and discharged via a common effluent outfall into the Great Miami River. A weir-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are also obtained upstream and downstream from the common FMPC effluent at locations shown in figure 2. The results of the FMPC water monitoring program for January–June 1968 are summarized in table 1.

Table 2. Radioactivity in the Great Miami River FMPC, January–June 1968

Location	Number of samples	Uranium concentration (pCi/liter)[a]			Total radioactivity (pCi/liter)[b]		
		High	Low	Average	High	Low	Average
Sewer outfall	182	<10	<10	<10	80	<10	20
Upstream from outfall	24	10	<10	6	80	<10	30
Downstream from outfall	31	30	<10	5	80	<10	20

[a] AEC radiation protection standard—20,000 pCi/liter.
[b] AEC radiation protection standard—3,000 pCi/liter.

Reported Nuclear Detonations, March 1969

The U.S. Atomic Energy Commission announced that the United States had recorded seismic signals originating from the Soviet underground nuclear test area in the Semipalatinsk region on March 7, 1969. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20–200 kilotons TNT equivalent).

Announcements were also made by the U.S. Atomic Energy Commission of two nuclear tests, one of low yield (less than 20 kilotons TNT equivalent) on March 20, 1969, and one of less than 100 kilotons TNT equivalent on March 21, 1969. Both were conducted underground by the Atomic Energy Commission at its Nevada Test Site.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1969 O—345-807

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 5, May 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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Published under the direction of

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Acting Director
Bureau of Radiological Health

by the Office of Criteria and Standards
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Reports

Radiological Health Aspects of Spent Radon Seeds

Richard F. Boggs, Gail D. Schmidt, and Kenneth D. Williams[1]

Following three incidents of radiation exposure to individuals wearing jewelry contaminated with radioactivity, the Bureau of Radiological Health (BRH) examined the early development, the present clinical use, and disposal of gold radon seeds, the suspected source of the contamination. The Ad Hoc committee called by the BRH to study the problem recommended that (1) the State and local radiological health agencies that have regulatory authority over radon seeds be familiar with the appropriate regulations, (2) that users of radon be advised to keep an account of radon seeds procured, not to supply unused or spent radon seeds to any unauthorized person and to return all decayed or unwanted radon seeds to the supplier or persons authorized to receive such shipments, (3) gold refiners and processors be alerted to the possibility of receiving contaminated gold and efforts be made to prevent such material from entering the commercial market, (4) the BRH consider the possibility of further investigation of the extent of the problem and consider providing technical assistance through appropriate agencies, and (5) the medical community be encouraged to investigate the feasibility of using other radionuclides for permanent implants.

From April 1967 to September 1968, three incidents in which jewelry contaminated with radioactivity caused overexposure to individuals wearing such jewelry were reported (*1–4*). In each case, it was reported that excessive radiation exposures resulted from wearing gold rings which apparently were fabricated partly or wholly from spent gold radon seeds. Relative to these incidents, the early development and present clinical use of gold radon seeds, methods used in fabricating the seeds, their physical characteristics, and methods for control of spent radon seeds are explained.

Development of radon seeds

Early in the development of radium therapy, it was realized that certain types of tumors could be most effectively treated by inserting the radioactive source directly into the tumor mass. Only bulky radium containers were available for this purpose at first. A technique for utilizing concentrated radon (radium emanation) as the radioactive source was reported by Stevenson in 1914 (*5*). He collected the radon gas in fine, capillary-glass tubes and placed them in hollow-steel needles which were inserted into the tumor and withdrawn at the end of the treatment.

In 1917, Duane (*6*) suggested a procedure for interstitial treatments using glass "radon seeds." The radon gas was collected in a glass tube about 0.4 mm in diameter, divided into sections 3- to 4-mm long, and then implanted directly into the tumor and allowed to remain permanently in situ. The successful practical techniques developed by Dr. H. Janeway at the New York Memorial Hospital, however, often resulted in severe pain due to the intense necrosis produced around each seed by the absorbed beta radiation (*7*).

---

[1] Messrs. Boggs, Schmidt, and Williams, are members of the Division of Medical Radiation Exposure, Bureau of Radiological Health, Rockville, Md. 20851.

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Trends in the use of radon seeds

Radon seeds have been used in the treatment of tumors in 11 different sites in the body. Murphy (*10*) reported in 1959 that five of these sites were frequently treated with radon, four sites only occasionally, and two of the sites were no longer being treated with radon.

The most effective application of radon seeds in radiotherapy is for bladder cancer. The seeds are also useful for small localized superficial lesions of the floor of the mouth, small tonsillar lesions, small lesions of the urethra located at the external orifice, and for pituitary gland irradiation.

In a recent survey of the use of radionuclides in medicine, supported by the Bureau of Radiological Health (BRH), 158 physicians reported using radon seeds in the treatment of 2,241 patients during 1966 (*11*). These physicians also reported a total of 3,069 administrations of radon seeds which represents 6.2 percent of the administrations in all brachytherapy procedures. From this survey data, it is projected that nationally, 231 physicians administered 4,500 radon implants in 3,300 patients in the United States during 1966.[2]

The radon needles used by Regaud in his early 1920 studies had a wall thickness of 0.5 mm of platinum, sufficient to filter out nearly all beta particles (*8*), thereby providing evidence that tumors could be efficiently treated with radon without painful necrosis. This helped to establish that the therapeutic benefit was derived only from the gamma radiation.

Gold tubing with a wall thickness of 0.3 mm was used by Failla in the making of filtered radon seeds (*9*) and proved to be the preferred encapsulation. This thickness of gold filtered out over 99 percent of the beta radiation; the seeds were sufficiently small and could be permanently implanted under local anesthesia. Gold radon seeds received immediate acceptance by radiotherapists and are commercially available today in basically the same form as those produced by Failla.

Physical characteristics of radon seeds

The physical characteristics of gold radon seeds (figure 1) used for permanent implants are as follows:

length—4.0 mm
external diameter—0.75 mm
wall thickness—0.30 mm
wall material—24K gold
total gold weight—0.0327 g
radioactivity—0.05 to 5 mCi at the time of use.

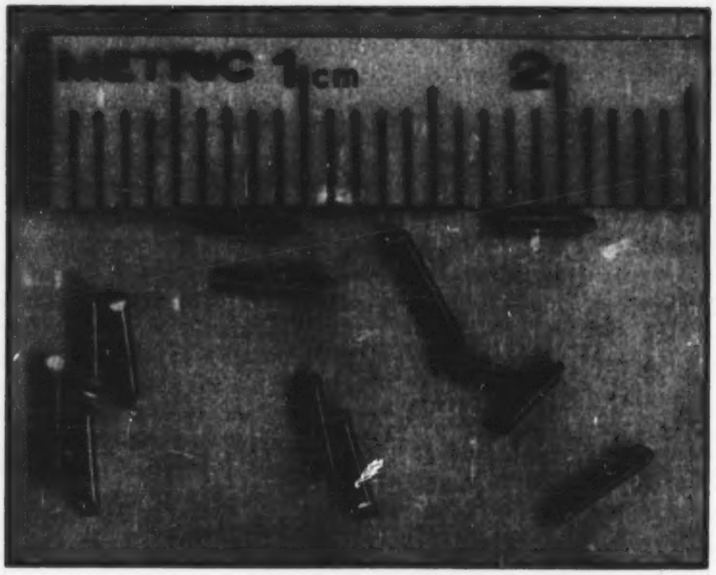

Figure 1. Radon filled gold seeds

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[2] U.S. Department of Health, Education, and Welfare, National Center for Radiological Health followup study to "Survey of the Use of Radionuclides in Medicine" (unpublished data).

Gold-198 and iridium-192 seeds have been used as substitutes for radon in permanent implant therapy. In 1966, as indicated by the above survey, these substitutes for radon accounted for approximately 18 percent of the reported permanent implant administrations. Currently, three other radionuclides, xenon-133, cesium-131, and iodine-125, are being investigated for this purpose (*12–13*). All of these radionuclides have the advantage of low-photon emission energies, which reduces protective shielding requirements; however, differences in half-life have raised the question of biological equivalents to radon and many physicians have been reluctant to change. The Conference on Medical Uses of Radium and Radium Substitutes has recommended that gold-198 be used as a substitute for radon seeds (*14*). This recommendation has been supported by a panel convened by the International Atomic Energy Agency (*15*). As more clinical experience is accumulated it is anticipated that the use of radon will decline.

Radioactivity from radon seeds

Since radon has a half-life of 3.8 days (table 1), approximately 2 months later essentially all of the radon (Rn) atoms will have decayed through the short-lived daughters to lead-210. The radioactivity of the lead-210 at that time is equal to 0.0005 of the initial radon activity.

Therefore, for an initial filling of 1 mCi of radon-222, the lead-210 ingrowth activity will be 0.0005 millicuries or 0.5 microcuries. One mCi (radon) is a commonly used activity for radon seeds at the time of implantation. Since these sources are delivered commercially via air and rail transportation, and since radon has a half-life of 3.8 days, the initial filling activity will be greater and may be two to four times higher than the activity at the time of implantation. The activity of lead-210 in the decayed or spent radon seed would correspond to the activity at the time of initial filling rather than at time of implantation.

The radiation produced by the long-lived daughters, radium D, E, and F, are given in table 1. In a spent radon seed, all of the alpha

Table 1. Physical characteristics of radium-226, radon-222 and radon daughters[a,b]

Characteristics	Nuclide	Historical name	Half-life	Principal radiation (MeV) (percent occurrence)
An alkaline earth metal and bone-seeker (as are calcium, strontium, and barium)	Radium-226	Radium	1,622 yr	α 4.78(94), 4.59(6) γ 0.19(4)
A member of the family of inert gases	Radon-222	Radon (air)	3.82 days	α 5.49(100)
	Polonium-218	Radium A	3.05 min	α 6.00(100)
Short-lived daughters effective half-life of 30 min. (essentially complete decay in 4 hours)	Lead-214	Radium B	26.8 min	β principal 0.65(50), 0.98(40) γ principal 0.24(11), 0.30(24), 0.35(44)
	Bismuth-214	Radium C	19.7 min	β various 0.74(20) to 3.18(15) γ various 0.61(45) to 2.43(2)
	Polonium-214	Radium C′	1.6 × 10⁻⁴ sec	α 7.68 (100)
Long-lived daughters about 20 yr. half-life alpha and beta-particle emitters with weak gamma rays	Lead-210	Radium D	19.4 yr	β 0.06(17), 0.02(83) γ 0.05(4)
	Bismuth-210	Radium E	5.0 days	β 1.16(100)
	Polonium-210	Radium F	138.4 days	α 5.30(100)
Stable lead	Lead-206	Radium G	Stable	

[a] The gamma radiation from medical radium and radon sources is primarily due to the short-lived daughters of radon.

[b] Excerpted from reference (*16*).

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particles and over 99 percent of the beta particles are absorbed by the 0.3 mm gold wall. The 47 keV gamma rays from lead-210 are almost entirely eliminated by the gold wall. Johns and Skarsgard state that the slowing down of the beta particles in the gold produces bremsstrahlung with a spectral energy of 50 to 500 keV (*17*). Theoretical calculations of the bremsstrahlung intensity by Johns and Skarsgard gave an exposure rate of 41.7 μR/hr at 1 cm from a 1 mCi (radon) seed. Not considered inconsistent with the theoretical value is their experimental measurement of five seeds using a NaI (Tl) crystal with a multichannel analyzer yielding an exposure rate of 76.5 μR/hr.

The spectrum of the spent radon seeds obtained by Johns and Skarsgard is shown in figure 2. The bremsstrahlung spectrum without filtration is at a maximum at zero energy and falls continuously to zero as the photon energy is increased to 1.16 MeV. The low energy end of this continuous spectrum is strongly filtered by the gold. The peak of 70 keV results from the K-shell x rays of gold which are produced by many of the photons above the K edge of gold (80.8 keV) and which are less fully absorbed for two reasons; (1) the reduced absorption coefficient below the K edge and (2) the fact that they are produced throughout the thickness of the wall and hence incur lower average transmission loss. Also, the 47 keV gamma ray of lead-210 has been sufficiently attenuated so that it is lost in the bremsstrahlung spectrum.

External radiation from beta sources

The dose rate near a plane source of beta particles of maximum energy in the region of 0.5 to 3.0 MeV is about 7 rad/hr per μCi/cm² as estimated by Chamberlain (*18*); this figure would be increased by a factor of perhaps 1.5 by backscattering of electrons from the surface carrying the source (*18*). According to Loevinger, the calculated dose rate for an infinite thin plane beta source is about 6 rad/hr per μCi/cm² at a distance of 0.1 mm from the surface of the source (*19*). This assumes that all of the lead-210 radioactivity is deposited on the surface of the source. Assuming that the lead-210 radioactivity is uniformly dispersed in an infinite gold slab with a thickness greater than 0.23 mm (which may be considered infinite thickness), the calculated dose rate at the surface of the source is about 0.34 rad/hr per μCi/g at the surface of the source (*20*).

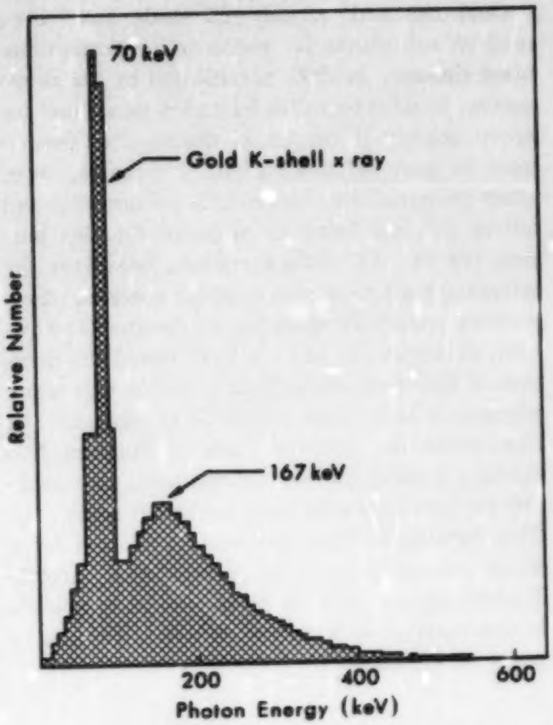

Figure 2. Spectrum for radon seeds

It has been previously shown that 1 millicurie of radon will yield about 0.5 microcuries of lead-210. This activity, when uniformly dispersed in a gold seed, yields a specific activity of 15.3 μCi/g. Based on these data, the surface dose rate from a gold slab 0.23 mm thick is:

$$R_\beta(0, \infty) = 0.34 \times 15.3 = 5.2 \text{ rad/hr}$$

Gold rings (wedding bands) usually have dimensions that approximate an infinite slab (with a thickness greater than 0.23 mm) for exposure points that are in contact with the ring. Harley measured beta radiation doses of up to 900 mR/hr which, though lower, appear consistent with this calculation (*2*). One would expect some dilution of the lead-210 by the metal alloyed with the gold, since gold jewelry is generally not more than 14 karat, while gold seeds are 24-karat gold. Contaminated gold may be further diluted in radioactivity by being mixed with uncontaminated

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gold. Approximately 100 to 200 gold seeds would be required to make a single gold wedding band.[3]

Control of spent radon seeds

The disposal of spent radon seeds is controlled by the regulations of the Agreement States and other States which have enacted similar regulations for the control of naturally occurring radionuclides. The Agreement States are authorized by the U.S. Atomic Energy Commission to assume control over certain radionuclides previously under the jurisdiction of the AEC. There are currently 19 Agreement States and 15 additional States which are considered to have comprehensive radiation control regulations (*21*) that are similar to the "Suggested State Regulations for Control of Radiation" of the Council of State Governments (*22*). These regulations provide that no licensee shall dispose of any radioactive material except by special procedures which include ground burial and release to the sewerage system, and special authorization.

The Bureau of Radiological Health has been able to document the existence of only 18 radon plants in the United States, however, it is believed that 30 to 40 plants operated during past years. Today, there are only three known operating plants: Memorial Hospital for Cancer and Allied Diseases, New York, N.Y.; the Radium Chemical Company, Inc., New York, N.Y.; and Radium Service Corporation of America in Kenilworth, Ill. New York State is one of the Agreement States, and therefore two of these facilities come under the same comprehensive regulations for control of the disposal of radioactive material as noted for the radon seed user. The disposal of spent radon seeds by Radium Service Corporation of America is governed by the regulations of the Illinois Department of Public Health which are similar to those of an Agreement State.

The Gold Filled Manufacturers Association has indicated that the largest refiner of gold has for some time made radioactivity checks on their gold and has never detected any radioactivity. Because of the monetary value of gold, there are government controls which require records of its sale and purchase. While most of the gold in this country is refined by several large companies, there are hundreds of small local concerns that may refine or process gold, making it difficult to provide radioactivity measurements of all scrap gold entering the market.

Conclusions

While it is known that in the past, gold radon seeds were collected and sold to gold manufacturers, no clear evidence has been obtained to prove that such seeds have resulted in the reported incidents. At the present time, all spent radon seeds at the three operating radon plants are retained in storage at the facilities.

On January 7, 1969, the Bureau of Radiological Health called a meeting of an Ad Hoc Committee on the Control of Spent Radon Seeds[4] to review the problem in depth and to make recommendations on any future actions which should be taken. The conclusion of this committee is that based upon the available evidence, the radioactive contamination of gold from spent radon seeds does not appear to be a wide-spread public health hazard. However, a few cases of skin reaction that could have resulted in significant biological damage have been observed as a result of gold contaminated in previous years. Therefore, the committee recommended the following:

1. Although radon seeds lose their medical usefulness in a short time, the long-lived daughter products continue to constitute a potential radiation hazard if uncontrolled. State and local radiological health agencies which have regulatory authority over radon seeds should insure that purchasers and users of radon seeds are familiar with the appropriate regulations.

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[3] A single gold seed is worth about 3 cents based upon a gold price of $35.00 per troy ounce.

[4] The members of the committee are Dr. John S. Laughlin (chairman), radiation physicist, Memorial Hospital, New York City; Mr. Thomas Cashman, director, Bureau of Radiological Health, New York State Department of Health, Albany; Mr. Russell F. Cowing, radiological physicist, New England Deaconess Hospital, Cancer Research Institute, Boston; Dr. Warren M. Holm, vice president, Radium Chemical Company, New York City; Dr. John Harley, director, Health and Safety Laboratory, U.S. Atomic Energy Commission, New York City; and Dr. Norman Simon, radiologist, New York City.

2. Although the Council of State Governments "Suggested State Regulations for Control of Radiation" (22) specifies the procedures for proper handling and disposal of all radioactive materials, it is recommended that the users of radon be advised, (a) to keep an account of radon seeds procured, (b) not to supply unused or spent radon seeds to any unauthorized person, and (c) to return all decayed or unwanted radon seeds to the supplier or persons authorized to receive such shipments.

3. Gold refiners and processors should be alerted to the possibility of receiving contaminated gold, and efforts should be made to prevent such material from entering the commercial market.

4. The Bureau of Radiological Health should consider the possibility of further investigation of the extent of the problem and consider providing technical assistance, including methodology of detection, through appropriate agencies.

5. The medical community, including agencies supporting research designed to reduce radiation exposure, should be encouraged to investigate the feasibility of using other radionuclides for permanent implants. It is recognized that radon-222 is still an important therapeutic modality and every effort should be made to encourage its proper use.

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Technical Notes

Survey of Veterinary X-Ray Units in Alabama

William T. Willis and J. Edward Cowan[1]

The Bureau of Environmental Health of the Alabama State Department of Public Health has completed a radiological health survey of 65 x-ray units and a fluoroscope used in the practice of veterinary medicine. This report discusses the survey registration procedure and results, the regulatory requirements for veterinary radiographic units, the compliance status for each requirement, and the compliance status for the total number of veterinary facilities and x-ray units at the time of the survey, and the completion of the survey. By agreement, the 24 veterinary units located in Jefferson County (Birmingham) were inspected independently and brought into compliance with the Alabama regulations for control of radiation; these units are excluded from this report.

The purpose of the survey was to determine the nature and extent of radiological health hazards occurring during the operation of veterinary x-ray units, and to reduce the hazards to the lowest practical level. The survey was successful in achieving the following objectives:

1. determining the number and location of all veterinary x-ray units;
2. performing a physical inspection of each x-ray unit;
3. determining the compliance status of each unit; and
4. bringing units into full compliance with Alabama regulations (*1*).

The regulations governing medical, dental, and veterinary x-ray units were adopted in 1965 by the Alabama State Board of Health. The specific regulatory requirements for Alabama veterinary units are identical to the suggested regulations of the Council of State Governments which were prepared in cooperation with the U.S. Atomic Energy Commission and the U.S. Public Health Service (*2*).

In initiating the survey, the State Health Officer advised each veterinarian who had registered an x-ray unit that the unit would be inspected. The initial inspection and follow-up compliance visits were conducted over a period of 6 months by a team of 2 registered x-ray technicians.

Registration

Prior to inspection of the x-ray units, a postcard registration form was sent to the 193 veterinarians listed in the "Directory of Licensed Veterinarians in Alabama." As indicated in table 1, a number of veterinarians were reluctant to respond to the registration request. After three registration requests, a combined total of 149 registration cards were returned leaving a remainder of 44 veterinarians who did not respond. Of the 149 registration cards returned, 67 veterinarians indicated possession of an x-ray unit. To complete the registration, the 44 veterinarians who did not return a card were contacted by telephone and it was learned that 22 owned x-ray units. Final registration results showed that 65 operable veterinary x-ray units and one hand-held fluoroscope were located at a total of 60 facilities.

The number of registered x-ray units per county, in those counties with units, ranged from 1 to 13.

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Table 1. Veterinarians response to registration requests

Number of registration requests	Requests mailed	Number of respondents
193	December 1966	72
124	February 1967	58
70	March 1967	19
387		149

The majority of units were concentrated in a few counties; 44 (or two-thirds of the total) were located in only 8 counties. Table 2 shows the number of counties with specified numbers of x-ray units.

Table 2. Counties with specified number of x-ray units

Number of counties	Number of units in county	Total units
16	1	16
3	2	6
2	3	6
1	4	4
3	5	15
1	6	6
1	13	13
27		66

Equipment requirements and results

The discussion of regulatory requirements and survey results is categorized into the areas of equipment, operating procedures, shielding, and personnel monitoring. Each individual regulatory item inspected is listed in table 3.

Filtration reduces undesirable densities in a radiograph through the absorption of lower energy x rays and results in improved radiographic quality. The use of filtration also results in less radiation exposure to the operator and to persons holding the animal. Measurements taken during the survey showed a significant radiation exposure reduction directly related to the use of filtration. In a typical measurement, the addition of 2 millimeters aluminum filtration reduced the output of the primary beam from 800 to 400 milliroentgens per second at 36 inches, using 10 milliamperes and 60 kilovolts. Scattered radiation showed a corresponding reduction of over 40 percent.

The survey determined that more veterinary x-ray units were in noncompliance with the item of filtration than any other requirement. The exact thickness of filtration required is dependent upon the operating kilovolts, but the majority of units should be provided with a minimum of 2 millimeters aluminum-equivalent filtration.

Table 3. Compliance of veterinary x-ray units by regulatory item (before and after survey)

Regulatory item	In compliance at time of initial inspection		In compliance after followup inspections	
	Number	Percent	Number	Percent
Equipment:				
Filtration	32	49	65	100
Collimation	62	95	65	100
Timer	64	98	65	100
Tube housing	65	100	65	100
Operating procedures:				
Operator stands 6 feet away, or behind barrier or wears leaded apron	65	100	65	100
Wears leaded apron and gloves when holding animals	55	85	64	98
Shielding	65	100	65	100
Personnel monitoring	64	98	64	98

Fifty-one percent of the total x-ray units inspected were equipped with less than the required thickness of aluminum-equivalent filtration. Of greater significance is the fact that 28 of 33 deficient units were without any filtration other than the one-half millimeter inherent. Five units had 1 millimeter of filtration each.

As an additional service to the veterinarians, filters were inserted in all x-ray units that were equipped with less than the required thickness of aluminum. All units were brought into compliance by positioning the required 1 or 2 millimeters of aluminum in the port to intercept the primary beam. Thus, the item found most frequently in noncompliance was corrected without difficulty and at minimal cost.

As in medical and dental radiography correct collimation is important in veterinary radiography, but its use is not based on genetic considerations of the animal being radiographed. Collimation is necessary in veterinary radiography to direct the primary beam to the area of clinical interest and to reduce the radiation exposure to the holder of the animal.

The adequacy of collimation was determined for the majority of units by the use of fluorescent strips. In this procedure the size of the beam was observed when the strips fluoresced as the tube was energized. In those instances where the x-ray room could not be darkened sufficiently to observe the fluorescent strips, the beam size was determined by measurement and calculation using similar triangles and the formula, $a/b = A/B$. In these cases, the diameter of the beam (B) at any distance from the tube (A) for any given cone was determined by measuring the

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distance from the tube target to the end of the cone (a), the diameter of the cone (b), and solving for B by using the equation, $B = \frac{Ab}{a}$.

Sixty-two of 65 units were equipped with collimators that restricted the primary beam to the area of clinical interest. Three units were not equipped with any type collimator.

Timers for veterinary x-ray units were found to be in full compliance. All units were equipped with timing devices that terminated the exposure after a preset time, as required. Sixty-four of 65 units were in compliance with the requirement for an exposure device. The one unit in noncompliance could be operated without continuous pressure on the exposure device by the operator.

The x-ray tube housing for each of the 65 units was measured for leakage. Radiation measurements taken with the port blocked showed that all units were well below the maximum allowable tube-housing leakage of 100 milliroentgens in 1 hour at 1 meter.

Procedural requirements and results

Operator protection is one of the more important procedural requirements. Operators of veterinary x-ray units may use three different methods for radiation protection. The operator may stand a minimum of 6 feet from the animal being radiographed, behind a protective barrier, or may wear a leaded apron.

The survey determined that the requirement of operator protection was in compliance at every x-ray facility. The operators of 61 units stood 6 feet from the animal. In addition, the operators of 20 of the 61 units also stood behind a barrier and the operators of 15 of the 61 units wore a leaded apron.

The animal being radiographed is generally immobilized. The usual procedure is to anesthetize the animal, then hold it in the desired position. The regulations permit the holding of animals, but a person may not be employed to perform this service regularly. Additionally, the person holding the animal must be provided with a leaded apron and gloves.

The survey showed that none of the 60 facilities regularly employed an individual to hold animals. However, 10 facilities did use individuals, usually the owner, to hold the animal without providing the person with the required protective leaded apron and gloves. This item was found to be the second most frequently occurring item of noncompliance and is perhaps the most significant because of the resultant radiation exposure. The increased significance of this item arises from the fact that the person holding the animal is standing on the immediate perimeter of the primary beam and will receive unnecessary radiation exposure unless protective apron and gloves are provided. For an x-ray unit operating at 65 kVp and 15 milliamperes, one measurement showed that an individual holding an animal without a protective apron and gloves would be exposed at the rate of 3 milliroentgens per second to the hands and 1.5 milliroentgens per second to the whole body. Leaded apron and gloves would reduce this unnecessary exposure to practically zero.

Shielding requirements and results

Shielding for a veterinary radiographic facility must be of sufficient thickness to reduce radiation levels in unrestricted areas so that an individual's exposure for continuous occupancy may not exceed 2 milliroentgens in any 1 hour, 100 milliroentgens in 7 consecutive days, and 500 milliroentgens in any 1 year. The adequacy of barrier thickness was determined by actually measuring radiation levels at nonrestricted locations. For every facility the calculations showed that the existing barrier thickness was sufficient to meet the standard. The exceedingly low workloads were a major factor in shielding adequacy. Table 4 illustrates the workloads.

Forty percent of the veterinary units are used to take 1 exposure per week, 67 percent are used

Table 4. Workloads of 65 veterinary x-ray units

Exposures per week	Number of units	Total units (percent)	Total exposure per week
0	3	5	[a] <1
1	23	35	24
2	8	13	16
3	9	14	27
4	1	1	4
5	4	6	20
6	4	6	24
7	0	0	0
8	3	5	24
9	0	0	0
10	2	3	20
15	3	5	45
20	2	3	40
30	2	3	60
60	1	1	60
Total	65	100	384

[a] Considered as zero in total exposures per week.

to take 3 or less exposures per week, and the entire 65 units are used to make only 364 exposures per week. The workload for the combined total of 65 units is 68 milliampere-minutes per week. The low level of tube on-time is a major factor in lessening the public health significance of veterinary x rays relative to other medical and industrial uses of x-ray equipment.

Personnel monitoring requirements and results

The regulations specify that personnel monitoring must be provided for all persons who operate a mobile x-ray unit and for each individual who receives or is likely to receive a dose in excess of 25 percent of 1.25 roentgens per calendar quarter. Operator exposure is related to on-time of an x-ray unit, thus the workload becomes an important consideration in estimating whether or not an x-ray operator should wear a film badge to record radiation exposure. The x-ray operators at two educational institutions were provided with film badges. Fifty-seven of 59 private practice facilities do not provide the operators with film badges, and are not required to do so by the regulations. Therefore, only 1 of 60 facilities was determined to be in noncompliance with the requirement of personnel monitoring. The one facility in noncompliance possessed a mobile x-ray unit which requires personnel monitoring regardless of workload or level of operator exposure. The entire 65 units required 85 operators, an average of only 1.3 operators per x-ray unit.

Compliance with the requirement of personnel monitoring occurred because the low tube on-time and existing operator protection equipment and method kept radiation exposure at all private practice facilities well below 25 percent of the personnel exposure standard. Actual radiation measurements for every facility made at the various operator positions under normal operating procedures, and subsequent personnel exposure calculations, provided documentation that 59 of 60 facilities were in full compliance with the personnel monitoring requirement, although 87 percent of all operators did not wear a film badge.

Compliance

The term "compliance" as used in this report means that each x-ray unit meets every requirement for veterinary x-ray units as specified in Alabama regulations for the control of radiation. The compliance status index will be used to evaluate the results of this survey, that is, a comparison of the number of x-ray units in compliance at the time of the initial inspection with the number of units in compliance after the completion of all follow-up inspections. Although this method for evaluating the accomplishments of the survey does not quantify the dose reduction, it carries a presumption that unnecessary radiation is eliminated when units are brought into compliance.

The veterinarian's compliance with the regulatory requirements was excellent. At the time of the initial inspection only 26 units were in compliance. Correction of the single requirement of filtration by the survey team increased the number of units in compliance from 26 to 50, and after completion of the follow-up inspections, 64 of 65 radiographic veterinary x-ray units were in compliance with every regulatory requirement. Table 3 presents this data in tabular form. The owner disposed of the hand-held fluoroscope as its use was specifically prohibited by the regulations.

Summary

All known veterinary x-ray units in Alabama have been registered and inspected. Sixty-five radiographic units and one fluoroscope were physically inspected for compliance with all applicable provisions of Alabama regulations for control of radiation.

At the time of the initial inspection, only 26 of 65 units were found to be in compliance. After completion of the initial inspection and all follow-up visits, 64 of 65 x-ray units were in compliance with the regulations. Disposal was made of the hand-held fluoroscope.

The item of filtration was found to be in noncompliance more frequently than any other requirement. Filtration was corrected at the time of the inspection by the survey team, thus the number of units in compliance was increased during the inspection from 26 to 50. The second most frequently occurring item of noncompliance and perhaps the item of greatest importance, was the holding of animals without wearing protective leaded apron and gloves.

Shielding was determined to be sufficient for all facilities. As radiation exposure is a direct func-

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tion of tube on-time, the exceedingly low workloads contributed to the shielding adequacy.

Only one facility was found to be in noncompliance with the requirement of personnel monitoring, although x-ray operators at the majority of facilities did not wear film badges. The low workloads minimized radiation exposure and was a factor in negating the need for film badges.

Unnecessary radiation exposure during the operation of veterinary x-ray units has been reduced as a result of the survey. However, the 65 x-ray units and the 85 operators are small in number when compared to other medical uses of x-ray equipment. This fact, joined with the low level of tube on-time and existing protective equipment, reduces the public health significance of veterinary x-rays and suggests a low priority for future reinspections.

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SECTION I. MILK AND FOOD

Milk Surveillance, January 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

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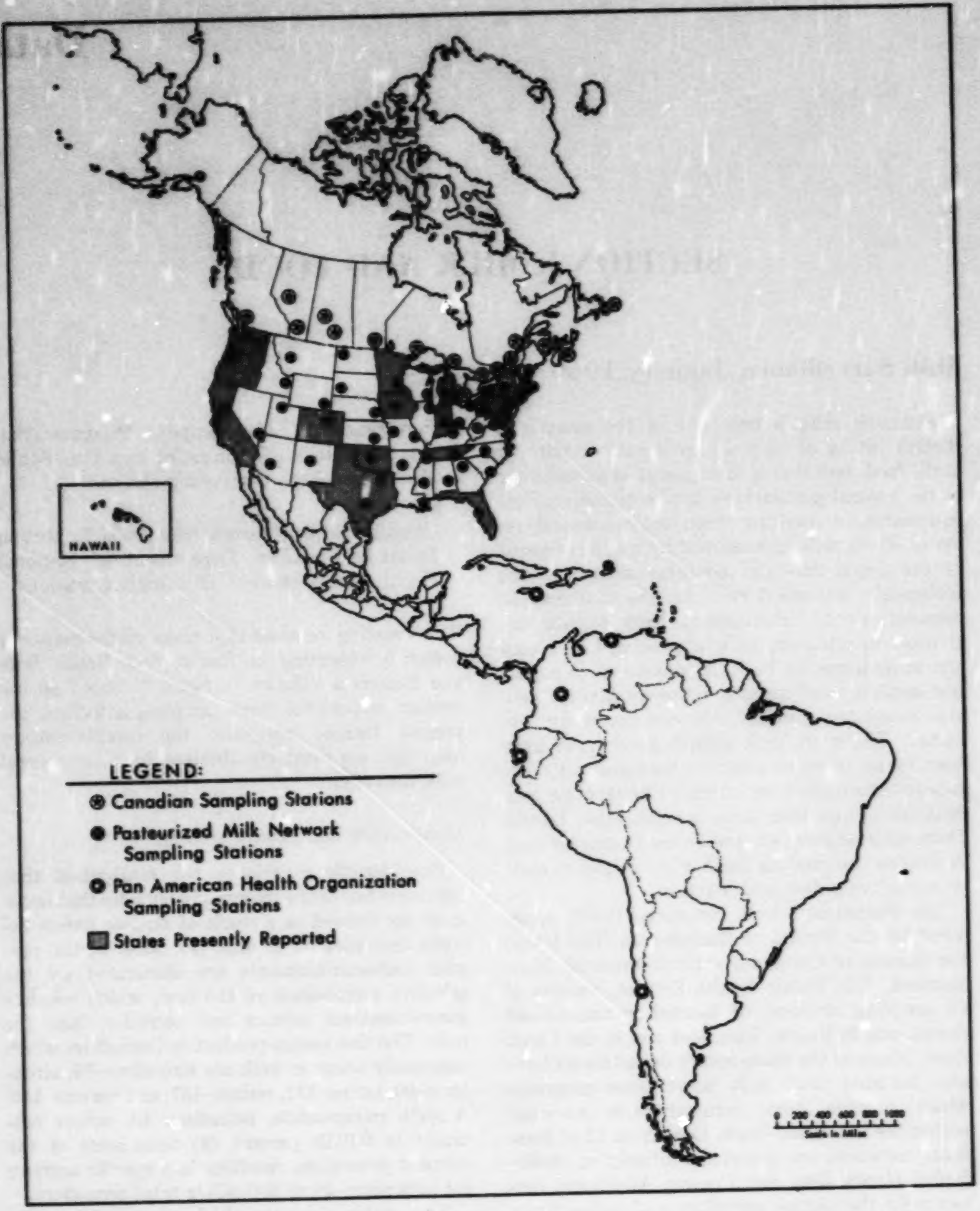
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Health Organization Sampling Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium–90, iodine–131 and cesium–137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation will also reflect whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milk-

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shed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviation
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥50 pCi/liter
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reportining level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)	Range II (pCi/day)	Range III (pCi/day)
Strontium-89	Bone	1.5	0.5	[b] 2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1.5	.5	[b] 200	0-20	20-200	200-2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[c]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] For strontium-89, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[c] The guides expressed here were not given in the FRC reports, but were calculated using approppropriate FRC recommendations.

radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent milk concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

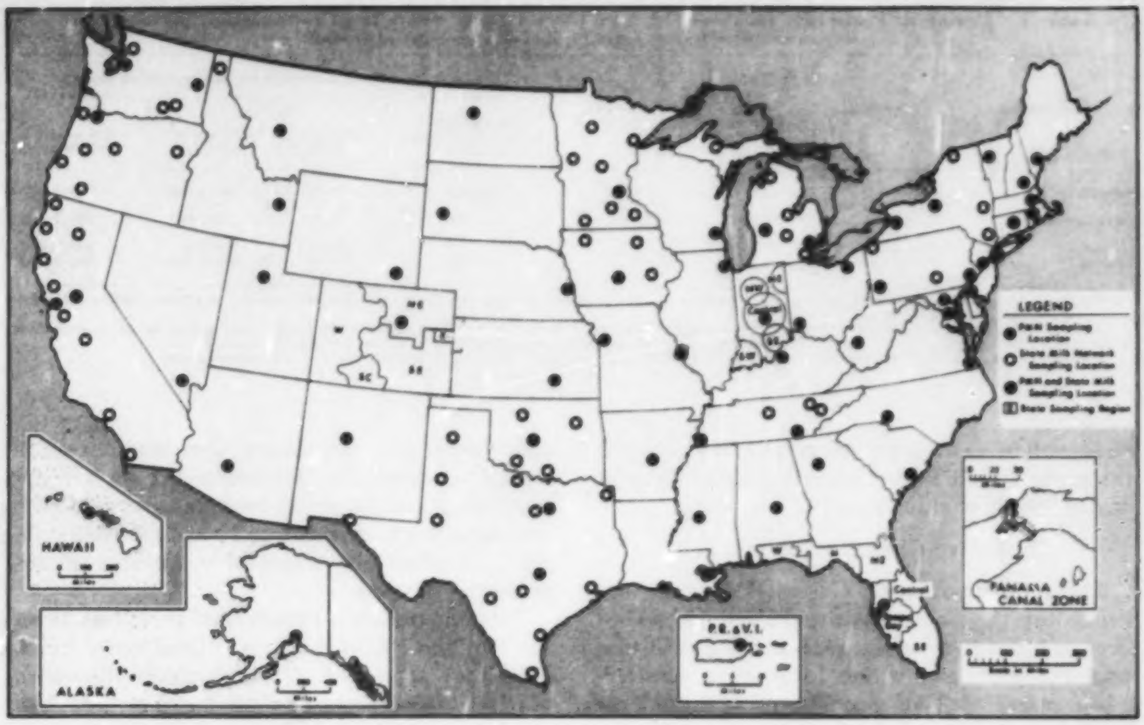

Figure 2. State and PMN milk sampling locations in the United States

estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. The relationship between the PMN stations and State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium–90, iodine–131 and cesium–137 for January 1969 and the 12-month period, February 1968 to January 1969. Except where noted the monthly average represents a single sample for the sampling station. Strontium–89 and barium–

Table 3. Concentration of radionuclides in milk for January 1969 and 12-month period, February, 1968 through January 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	6	8	0(3)	0	9(3)	14
Alaska:	Palmer[c]	P	7	5	0(4)	0	8(4)	12
Ariz:	Phoenix[c]	P	0	1	0(5)	0	0(5)	2
Ark:	Little Rock[c]	P	16	21	0(4)	0	16(4)	19
Calif:	Sacramento[c]	P	0	2	0(5)	0	0(5)	4
	San Francisco[c]	P	0	1	0(5)	0	0(5)	4
	Del Norte	P	9	18	0	0	11	19
	Fresno	P	0	0	0	0	0	4
	Humboldt	P	4	4	0	0	0	11
	Los Angeles	P	0	1	0	0	0	6
	Mendocino	P	0	2	0	0	0	4
	Sacramento	P	0	2	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	6
	Shasta	P	3	4	0	0	0	4
	Sonoma	P	0	1	0	0	0	4
Colo:	Denver[c]	P	6	5	0(5)	0	0(5)	5
	West	R	(d)		(e)	(e)	(e)	(e)
	Northeast	R	(d)		NS	(e)	NS	(e)
	East	R	(d)		NS	(e)	NS	(e)
	Southeast	R	(d)		NS	(e)	NS	(e)
	South Central	R	(e)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	8	9	0(5)	0	12(5)	12
	Central	R	NS		NS		NS	
Del:	Wilmington[c]	P	9	10	0(5)	0	4(5)	8
D.C.:	Washington[c]	P	7	9	0(5)	0	3(5)	7
Fla:	Tampa[c]	P	9	8	0(4)	0	57(4)	66
	West	R	6	13	0	3	20	23
	North	R	8	15	0	0	25	27
	Northeast	R	7	8	0	3	72	81
	Central	R	8	9	0	2	47	80
	Tampa Bay area	R	7	8	0	0	63	72
	Southeast	R	7	9	0	0	105	111
Ga:	Atlanta[c]	P	12	14	0(4)	0	19(4)	20
Hawaii:	Honolulu[c]	P	2	4	0(4)	0	0(4)	3
Idaho:	Idaho Falls[c]	P	5	6	0(4)	0	7(4)	9
Ill:	Chicago[c]	P	8	9	0(4)	0	15(4)	11
Ind:	Indianapolis[c]	P	NA	8	0(4)	0	7(4)	6
	Northeast	P	10	11	0	0	0	11
	Southeast	P	8	11	0	0	20	18
	Central	P	7	9	0	0	13	10
	Southwest	P	9	9	0	0	0	12
	Northwest	P	7	10	0	0	17	13
Iowa:	Des Moines[c]	P	3	7	0(5)	0	1(5)	5
	Iowa City	P	6(2)	7	0	0	14	6
	Des Moines	P	4(4)	7	0	0	12	4
	Spencer	P	4(6)	6	0	0	0	4
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	9	8	0(4)	0	3(4)	4
Ky:	Louisville[c]	P	10	12	0(4)	0	11(4)	7
La:	New Orleans[c]	P	19	20	0(3)	0	16(3)	23
Maine:	Portland[c]	P	11	12	2(4)	1	23(4)	28
Md:	Baltimore[c]	P	8	10	0(4)	0	7(4)	8
Mass:	Boston[c]	P	10	12	0(4)	0	18(4)	24
Mich:	Detroit[c]	P	9	9	0(4)	0	10(4)	11
	Grand Rapids[c]	P	10	11	0(4)	0	14(4)	15
	Bay City	P	NA	4	NA	(e)	NA	7
	Charlevoix	P	NA	5	(e)(3)	(e)	10	9
	Detroit	P	NA	4	(e)(4)	(e)	3	5
	Grand Rapids	P	NA	5	(e)(4)	(e)	6	8
	Lansing	P	NA	4	(e)(3)	(e)	5	3
	Marquette	P	NA	7	(e)(3)	(e)	30	20
	Monroe	P	NA	3	(e)(2)	(e)	0	1
	South Haven	P	NA	0	(e)(2)	(e)	0	0
Minn:	Minneapolis[c]	P	12	11	0(4)	0	11(4)	13
	Bemidji	P	18	16	0	0	23	24
	Mankato	P	NA	6	0	0	0	0
	Rochester	P	4	9	0	0	13	0
	Duluth	P	21	22	0	0	35	32
	Worthington	P	7	6	0	0	36	0
	Minneapolis	P	14	12	0	0	15	14
	Fergus Falls	P	8	10	0	0	30	10
	Little Falls	P	10	10	0	0	42	17
Miss:	Jackson[c]	P	12	17	0(4)	0	20(4)	16
Mo:	Kansas City[c]	P	6	8	0(5)	0	2(5)	5
	St. Louis[c]	P	8	9	0(4)	0	0(4)	6
Mont:	Helena[c]	P	5	4	0(4)	0	2(4)	8
Nebr:	Omaha[c]	P	6	7	0(5)	0	0(5)	5
Nev:	Las Vegas[c]	P	3	1	0(4)	0	2(4)	3
N.H.:	Manchester[c]	P	10	13	0(4)	0	22(4)	34
N.J.:	Trenton[c]	P	9	10	0(5)	0	8(5)	11

See footnotes at end of table.

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Table 3. Concentration of radionuclides in milk for January 1969 and 12-month period, February 1968 through January 1969—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.Mex:	Albuquerque[c]	P	4	3	0(4)	0	3(4)	2
N.Y.:	Buffalo[c]	P	7	8	0(5)	0	7(5)	10
	New York City[c]	P	NA	12	0(4)	0	13(4)	16
	Syracuse[c]	P	7	9	0(4)	0	5(4)	8
	Albany	P	11(5)	9	0	0	(e)(5)	(e)
	Buffalo	P	NA	7	NA	0	NA	(e)
	Massena	P	10(3)	11	0(3)	0	22(3)	22
	Newburg	P	15(5)	11	0(5)	0	(e)(5)	(e)
	New York City	P	14(4)	12	0(4)	0	(e)(3)	(e)
	Syracuse	P	11(2)	7	0(3)	0	(e)(3)	(e)
N.C.:	Charlotte[c]	P	14	15	0(4)	0	9(4)	11
N.Dak:	Minot[c]	P	10	11	0(6)	0	14(6)	14
Ohio:	Cincinnati[c]	P	9	9	0(4)	0	7(4)	6
	Cleveland[c]	P	8	9	0(5)	0	9(5)	8
Okla:	Oklahoma City[c]	P	11	10	0(4)	0	3(4)	6
	Oklahoma City	P	(d)		NA		NA	
	Enid	P	(d)		NA		NA	
	Tulsa	P	(d)		NA		NA	
	Lawton	P	(d)		NA		NA	
	Ardmore	P	(d)		NA		NA	
Ore:	Portland[c]	P	4	8	9(8)	0	10(8)	15
	Baker	P	0	3	(e)	(e)	24	3
	Coos Bay	P	3	10	(e)	(e)	25	15
	Eugene	P	5	4	(e)	(e)	(e)	15
	Medford	P	0	2	(e)	(e)	43	13
	Portland composite	P	2	5	(e)	(e)	(e)(3)	8
	Portland local	P	3	5	(e)	(e)	17(3)	9
	Redmond	R	0	2	(e)	(e)	18	8
	Tillamook	R	5	8	(e)	(e)	24	27
Pa:	Philadelphia[c]	P	9	10	0	0	6	8
	Pittsburgh[c]	P	11	12	0	0	10	12
	Dauphin	P	0	7	0	0	19	17
	Erie	P	8	13	0	0	17(2)	[illegible]
	Philadelphia	P	5	10	0(5)	0	13(5)	17
	Pittsburgh	P	7	12	0(4)	0	18(4)	16
R.I.:	Providence[c]	P	6	10	0(5)	0	16(5)	19
S.C.:	Charleston[c]	P	12	14	0(4)	0	17(4)	25
S.Dak:	Rapid City[c]	P	10	9	0(5)	0	2(5)	10
Tenn:	Chattanooga[c]	P	12	13	0(4)	0	11(4)	13
	Memphis[c]	P	9	11	0(5)	0	4(5)	6
	Chattanooga	P	11	12	3(4)	0	10(4)	7
	Clinton	P	14	13	0(2)	0	12(2)	19
	Knoxville	P	12	11	0(2)	0	9(2)	15
	Nashville	P	13	9	0(2)	0	15(2)	11
Tex:	Austin[c]	P	0	3	0(4)	0	5(4)	3
	Dallas[c]	P	5	8	0(4)	0	11(4)	7
	Amarillo	R	NA	4	NA	0	NA	0
	Corpus Christi	R	NA	4	NA	0	NA	3
	El Paso	R	NA	2	NA	0	NA	0
	Fort Worth	R	2	6	0	0	0	8
	Harlingen	R	NA	4	NA	0	NA	0
	Houston	R	6	10	0	0	20	19
	Lubbock	R	NA	4	NA	0	0	2
	Midland	R	2	3	0	0	0	0
	San Antonio	R	NA	[illegible]	NA	0	NA	0
	Texarkana	R	NA	12	NA	0	NA	18
	Uvalde	R	0	1	0	0	0	0
	Wichita Falls	R	NA	10	NA	0	NA	3
Utah:	Salt Lake City[c]	P	5	5	0(4)	0	9(4)	11
Vt:	Burlington[c]	P	8	10	0(4)	0	12(4)	10
Va:	Norfolk[c]	P	10	11	0(5)	0	10(5)	9
Wash:	Seattle[c]	P	7	8	0(5)	0	10(5)	21
	Spokane[c]	P	6	6	0(8)	0	8(8)	10
	Benton County	P	0	0	0	0	0	6
	Franklin County	R	NS	0	NS	0	NS	0
	Sandpoint, Idaho	R	10	8	0	0	25	25
	Skagit County	R	6	4	0	0	15	13
W.Va:	Charleston[c]	P	10	12	0(3)	0	10(3)	5
Wis:	Milwaukee[c]	P	7	7	0(5)	0	7(5)	10
Wyo:	Laramie[c]	P	3	4	0(3)	0	10(3)	10
CANADA:								
Alberta:	Calgary	P	8	8	(d)		15	16
	Edmonton	P	8	8	(d)		13	21
British Columbia:	Vancouver	P	12	14	(d)		34	50
Manitoba:	Winnipeg	P	9	8	(d)		25	25
New Brunswick:	Fredericton	P	13	16	(d)		13	24
Newfoundland:	St. Johns	P	15	21	(d)		30	43

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for January 1969 and 12-month period, February 1968 through January 1969—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA (Continued)								
Nova Scotia:	Halifax	P	11	11	([d])		14	23
Ontario:	Ft. William	P	16	16	([d])		27	31
	Ottawa	P	8	8	([d])		18	20
	Sault Ste. Marie	P	15	15	([d])		29	33
	Toronto	P	4	5	([d])		<10	16
	Windsor	P	5	6	([d])		10	14
Quebec:	Montreal	P	8	9	([d])		16	21
	Quebec	P	12	12	([d])		25	20
Saskatchewan:								
	Regina	P	6	7	([d])		14	17
	Saskatoon	P	8	9	([d])		12	18
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	NS	4	NS	0	NS	2
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Kingston	P	4	0	0	0	45	108
Venezuela	Caracas	P	0	0	0	0	0	0
Canal Zone:	Cristobal[c]	P	2	2	0(4)	1	44(4)	12
Puerto Rico:	San Juan[c]	P	6	5	0(3)	0	7(3)	9
PMN network average[f]			8	9	0	0	9	12

[a] P, pasteurized milk.
R, raw milk

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones giving in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine–131: Colorado–25 pCi/liter
Michigan–14 pCi/liter
Oregon–15 pCi/liter

Cesium–137: Colorado–25 pCi/liter
New York–20 pCi/liter
Oregon–15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote.[c]

NA, no analysis.
NS, no sample collected.

140 data have been omitted from table 3 since levels at the great majority of the stations for January 1969 were below the respective practical reporting levels. Strontium–89 levels for all stations were nondetectable during this period. The following station averages reflect samples in which barium–140 was detected: Florida, Southeast (State, 14 pCi/liter and West (State) 14 pCi/liter.

Iodine–131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine–131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium–90 monthly averages ranged from 0 to 21 pCi/liter in the United States for the month of January 1969 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark.) representing 10.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium–137 monthly averages ranged from 0 to 105 pCi/liter in the United States for the month of January 1969 and the highest 12-month average was 111 pCi/liter (Southeast Florida) representing 3.1 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium–137 levels that have been observed in Florida (*12*) and Jamaica. Iodine–131 results for individual samples were generally below the practical reporting level. The following station averages reflect samples in which iodine–131 was detected: Portland, Maine (PMN) 2 pCi/liter, 4 samples; Chattanooga, Tenn. (State) 3 pCi/liter, 4 samples.

Acknowledgement

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks.

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational
and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation and Occupational Health Section
Division of Environmental Sanitation
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
Institutional Diet, *PHS*	April–June 1968	January 1969
Tri-City Diet, *HASL*	April–December 1967	June 1968

1. Estimated Daily Intake of Radionuclides in California Diets, November–December 1967 and January–September 1968

Bureau of Radiological Health
California State Department of Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals.)

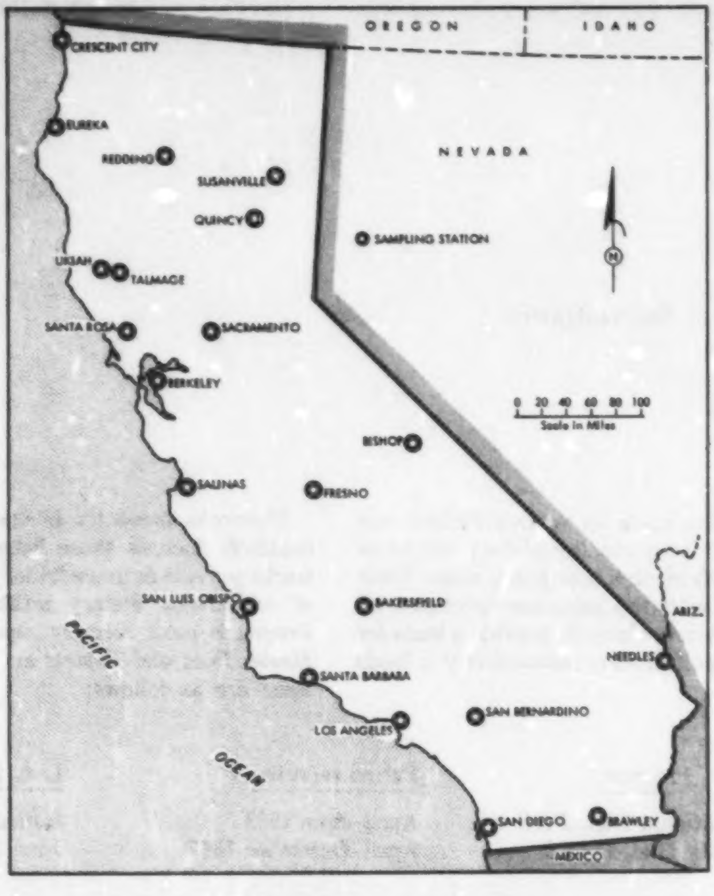
OREGON
IDAHO
NEVADA
CRESCENT CITY
EUREKA
REDDING
SUSANVILLE
QUINCY
SAMPLING STATION
N
UKIAH
TALMAGE
SANTA ROSA
SACRAMENTO
BERKELEY
0 20 40 60 80 100
Scale in Miles
BISHOP
SALINAS
FRESNO
SAN LUIS OBISPO
BAKERSFIELD
ARIZ.
NEEDLES
PACIFIC
SANTA BARBARA
LOS ANGELES
SAN BERNARDINO
OCEAN
SAN DIEGO
BRAWLEY
MEXICO

Figure 1. California diet sampling stations

Table 1. Estimated daily intake of radionuclides in California diets[a] November–December 1967

City	Consumption (kg/capita·day)[b]	Intake (pCi/capita·day)					Intake (g/capita·day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{54}Mn	K[c]	Na	Ca
Bakersfield	2.1	ND	5	0.5	8	10	3.1	4.0	1.1
Berkeley	2.0	ND	6	[d].2	7	ND	2.5	3.7	NA
Bishop	NS								
Brawley	1.9	ND	6	1.0	7	9	2.7	3.4	1.0
Crescent City	2.2	ND	14	1.1	13	ND	3.0	4.3	1.2
Eureka	2.1	ND	9	1.2	15	ND	3.0	4.7	.9
Fresno	2.8	6	4	.9	[d]5	ND	3.4	3.9	.8
Los Angeles	1.7	ND	5	.5	8	ND	2.6	4.1	.9
Needles	2.2	ND	6	1.1	[d]5	ND	2.9	2.9	.9
Quincy	2.4	ND	8	1.6	[d]3	ND	3.4	3.6	1.3
Redding	2.0	ND	8	.5	[d]5	ND	2.8	2.8	.9
Sacramento	2.5	ND	4	1.9	33	ND	3.3	5.8	1.2
Salinas	2.3	ND	4	1.1	10	ND	3.0	4.8	.8
San Bernardino	1.7	ND	4	1.0	16	ND	3.0	3.7	.8
San Diego	1.4	ND	5	.6	5	ND	3.1	2.4	NA
San Luis Obispo	1.7	ND	5	1.4	8	ND	2.9	4.4	1.1
Santa Barbara	2.1	ND	7	1.3	ND	ND	3.0	3.5	1.0
Santa Rosa	1.7	ND	5	.6	13	ND	2.1	2.4	.7
Susanville	2.0	ND	7	1.0	14	ND	2.8	4.2	1.0
Ukiah	2.1	ND	6	.8	8	ND	2.8	3.7	1.0

[a] Based on analyses of Hospital Standard Diets located in listed cities. Intakes for barium-lanthanum–140, zirconium–95, and cerium 141,–144 were nondetectable.

[b] Kilograms of food per person per day in this diet.

[c] Natural potassium contains 0.0119 percent of radioactive potassium–40.

[d] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

ND, nondetectable.

NA, no analysis.

NS, no sample.

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium–89, strontium–90, radium–226, and stable calcium, strontium, and sodium.

Table 2. Estimated daily intake of radionuclides in California diets,[a] January–March 1968

City	Consumption (kg/capita·day)[b]	Intake (pCi/capita·day)							Intake (g/capita·day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141,144}Ce$	K[c]	Na	Ca
Bakersfield	2.0	ND	4	0.8	17	0	0	0	3.8	3.8	1.2
Berkeley	1.8	ND	5	.8	9	ND	ND	ND	2.3	3.2	.6
Bishop	2.0	ND	8	1.1	12	ND	ND	ND	3.0	3.1	1.2
Brawley	NS										
Crescent City	2.0	ND	10	1.3	16	ND	8	ND	3.1	2.7	1.9
Eureka	2.2	ND	6	.6	30	ND	ND	ND	2.7	3.8	.7
Fresno	NS										
Los Angeles	2.3	ND	7	1.1	24	ND	ND	ND	3.5	4.1	1.1
Needles	2.4	ND	6	.7	22	ND	ND	ND	2.9	2.8	.9
Quincy	2.3	ND	4	1.4	19	ND	ND	ND	3.4	3.3	1.1
Redding	2.3	3	4	.6	11	ND	ND	ND	2.8	2.8	.8
Sacramento	2.6	ND	8	1.1	13	ND	ND	ND	3.3	5.1	1.3
Salinas	2.2	ND	4	.8	3	ND	7	ND	2.5	3.9	.8
San Bernardino	1.6	ND	3	1.5	11	ND	ND	ND	2.1	2.7	.6
San Diego	2.6	ND	12	.2	26	ND	ND	ND	3.8	3.5	1.4
San Luis Obispo	1.9	ND	7	1.3	18	ND	ND	ND	3.0	4.1	1.5
Santa Barbara	2.1	ND	8	.6	21	ND	ND	ND	3.0	3.3	.9
Santa Rosa	1.7	ND	4	1.1	12	ND	ND	ND	2.5	5.1	.9
Susanville	2.0	ND	6	1	18	ND	ND	ND	2.5	3.4	1.0
Ukiah	2.4	ND	7	1.0	18	ND	ND	ND	3.7	3.9	1.6

[a] Based on analyses of Hospital Diets located in listed cities.

[b] Kilograms of food per person per day in this diet.

[c] Natural potassium contains 0.0119 percent of radioactive potassium–40.

ND, nondetectable.

NS, no sample.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (November–December 1967), table 2 (January–March 1968), table 3 (April–June 1968), and table 4 (July–September 1968).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. A summary of strontium-90 and cesium-137 intake trends in California diets from January 1964 through June 1968 is given in figures 2 and 3.

Table 3. Estimated daily intake of radionuclides in California diets[a] April–June 1968

City	Consumption (kg/capita·day)[b]	Intake (pCi/capita·day)				Intake (g/capita·day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	K[c]	Na	Ca
Bakersfield	2.1	ND	4	0.8	9	3.0	3.7	1.0
Berkeley	1.2	3	3	.3	15	1.5	2.0	.3
Bishop	1.7	ND	10	1.3	21	2.5	2.2	1.1
Brawley	1.8	ND	ND	.4	13	2.4	2.6	NA
Crescent City	2.6	16	18	1.4	21	3.5	4.9	1.3
Eureka	2.2	6	10	1.6	17	3.7	5.6	1.4
Fresno	2.3	ND	5	1.8	5	3.1	3.1	1.0
Los Angeles	1.8	ND	4	1.3	ND	2.5	2.7	.7
Needles	2.3	ND	6	.6	24	2.9	3.8	.8
Quincy	2.2	2	7	.9	23	2.9	4.1	.8
Redding	2.1	6	5	.9	19	2.3	3.1	.9
Sacramento	2.5	ND	6	1.3	24	3.2	4.9	1.2
Salinas	2.6	ND	6	1.0	20	3.6	5.7	.9
San Bernardino	1.7	ND	6	2.8	24	3.5	4.6	1.0
San Diego	2.2	ND	6	1.0	5	3.4	3.4	.9
San Luis Obispo	2.1	ND	5	.9	20	3.3	4.7	1.1
Santa Barbara	2.0	ND	5	1.0	11	2.0	2.5	.8
Santa Rosa	2.2	ND	6	2.1	13	2.6	3.1	1.0
Susanville	2.1	4	6	.5	15	2.5	3.6	1.1
Talmage	2.1	ND	7	1.2	15	3.1	3.7	1.3

[a] Based on analyses of Hospital Standard Diets located in listed cities. Intakes for manganese-54, zirconium-95 and cerium-141, -144 were nondetectable.

[b] Kilograms of food per person per day in this diet.

[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.

[d] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

ND, nondetectable.

NA, no analysis.

Table 4. Estimated daily intake of radionuclides in California diets[a] July–September 1968

City	Consumption (kg/capita·day)[b]	Intake (pCi/capita·day)				Intake (g/capita·day)		
		^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	K[c]	Na	Ca
Bakersfield	2.2	5	0.9	15	ND	3.3	4.1	1.1
Bishop	1.5	4	1.4	5	ND	2.3	2.0	NA
Brawley	1.8	7	1.7	34	17	2.5	3.7	1.0
Crescent City	2.6	10	2.0	20	ND	4.2	5.8	.8
Eureka	2.0	6	2.5	36	17	2.5	4.0	.9
Fresno	2.2	4	1.3	23	ND	NA	NA	1.1
Los Angeles	2.2	3	.5	22	ND	2.2	5.1	1.1
Needles	2.3	7	1.7	16	ND	3.1	5.0	1.0
Oakland	2.2	7	1.5	27	9	3.1	3.5	1.1
Quincy	2.0	6	1.4	41	20	2.8	3.0	.8
Redding	2.4	5	1.9	48	14	3.1	3.4	.8
Sacramento	2.4	4	1.5	19	ND	2.6	3.6	.8
Salinas	2.3	8	1.6	23	ND	5.0	5.5	1.7
San Bernardino	1.8	4	1.5	40	9	2.8	3.5	.8
San Diego	2.3	9	1.3	43	13	3.4	3.1	1.0
San Luis Obispo	2.3	7	1.6	45	18	3.4	4.0	1.2
Santa Barbara	2.1	5	1.1	36	13	2.8	3.0	.9
Santa Rosa	1.8	5	1.2	30	8	2.0	2.7	.8
Susanville	2.2	4	.8	22	ND	2.7	3.9	NA
Talmage	2.1	5	1.6	38	14	3.3	4.0	.8

[a] Based on analyses of Hospital Standard Diets located in listed cities. Intakes for strontium-89, manganese-54, and cerium-141, -144, were nondetectable.

[b] Kilograms of food per person per day in this diet.

[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.

ND, nondetectable.

NA, no analysis.

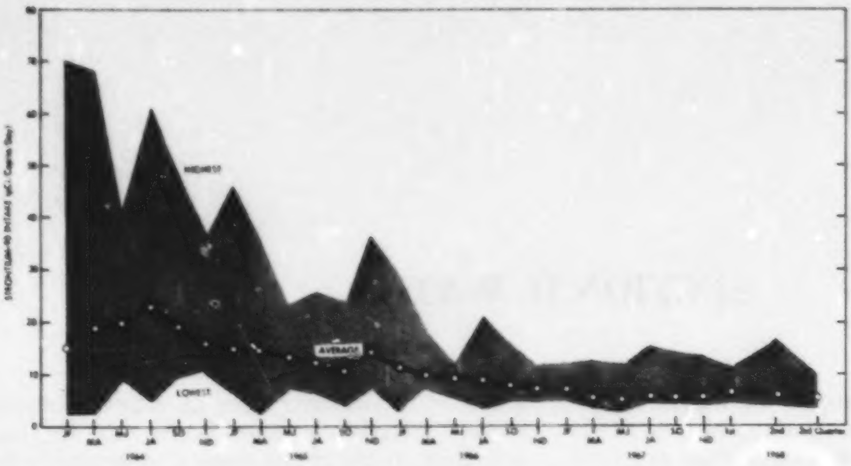

Figure 2. Averages and ranges of daily strontium-90 intake in California diets 1964–September 1968

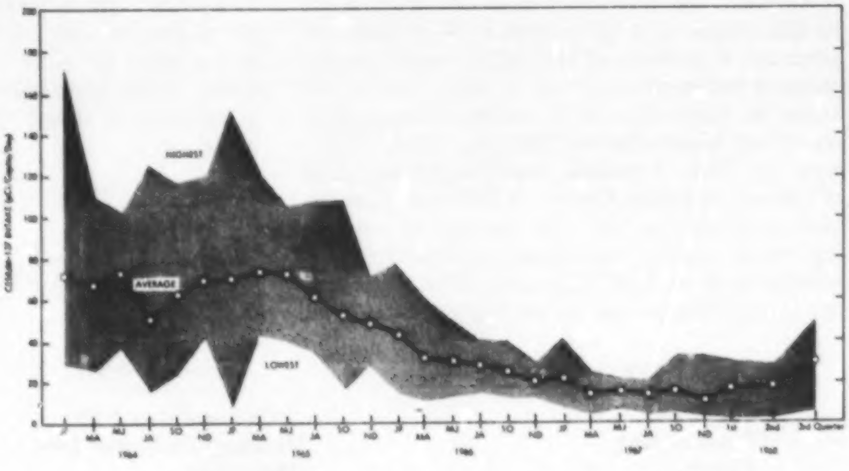

Figure 3. Averages and ranges of daily cesium-137 intake in California diets 1964–September 1968

REFERENCE

(1) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Radiol Health News 4:4 (October 1965) 2151 Berkeley Way, Berkeley 4, Calif.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
March–June 1967	February 1968
July–October 1967	May 1968

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Last presented
California	July–December 1967	December 1968
Coast Guard	January–December 1967	November 1968
Florida	1965–1966	July 1968
Minnesota	July–December 1967	October 1968
New York	June–December 1967	October 1968
Radiostrontium in Tap Water, *HASL*	January–June 1967	April 1968
Washington	July 1966–June 1967	August 1968

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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Radioactivity in North Carolina Surface, Ground, and Cistern Waters[1] January-December 1967

Sanitary Engineering Division
Radiological Health Section
North Carolina State Board of Health

In recognition of the growing use of radioactive materials in the State of North Carolina, the Sanitary Engineering Division and the State Laboratory of Hygiene of the State Board of Health, with the cooperation of municipalities, began in June 1958 a program of measurement of radioactivity in surface waters used as public water supplies. Some 147 sampling points were established to sample raw surface water. In July 1962, the program was expanded to include the sampling of cistern water from Ocrocoke Island. Then, in January 1963, other types of environmental samples were also collected, two of which were treated water from surface water supplies and ground water from wells used as municipal water supplies.

All waters contain traces of radioactivity originating from naturally radioactive minerals dissolved from rock strata or from radioactive particulate material or gases in the atmosphere. Common among these materials are trace elements of potassium–40, radium, thorium, and uranium. Such trace elements are dissolved by water both on its way to and flowing in the watercourses. Precipitation is the major mechanism by which particulate matter or radioactive gases, such as thoron and radon, are removed from the atmosphere. The combined radioactivity of these materials constitutes what is known as background radioactivity of the water. The total radioactivity would include both background radioactivity and contributions from fallout and other man-made sources.

A knowledge of the concentration of the background radioactivity as well as the total activity is an important factor in the appraisal of water quality, since standards pertaining to radiation exposure or concentration within drinking water are expressed in terms of "additions to the natural background."

Sampling procedures

Grab samples of both treated and untreated surface water are collected on a monthly basis in 1-gallon polyethylene containers at nine water treatment plants. Twelve ground water and three cistern water supplies were routinely sampled in 1967. Cistern water samples are collected in 1-

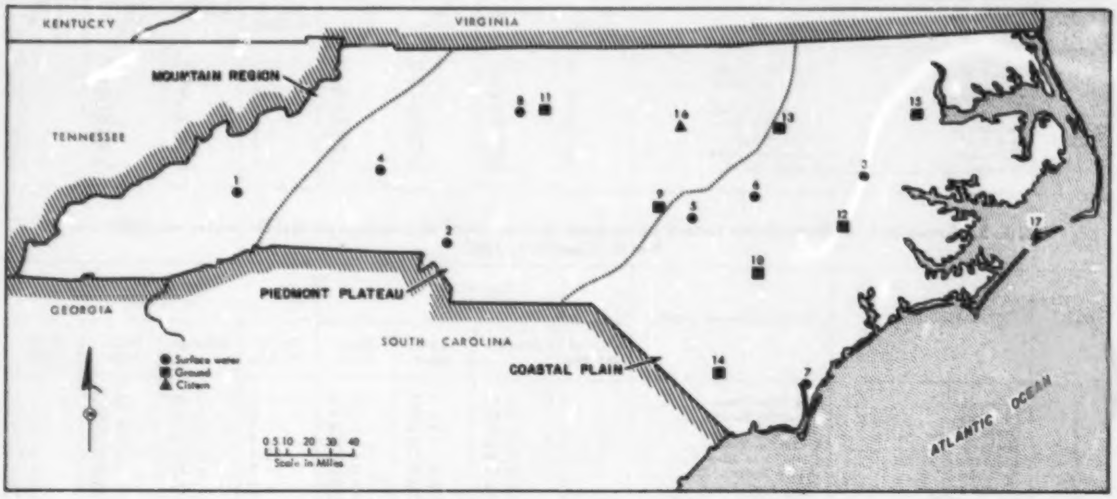

Figure 1. North Carolina water sampling stations

liter polyethylene containers and sent to the State laboratory for analysis as are all water samples. In the laboratory, samples are acidified with 2 ml of hydrochloric acid to prevent loss of radioactivity through precipitation and adhesion. The samples are then transferred to 3½ liter polyethylene Marinelli beakers for gamma-ray spectroscopy.

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[1] Summarized from "Background Radioactivity in Surface Water Supplies of North Carolina, 1958–1962" and "Environmental Radiation Surveillance 1967."

After scanning, 1 liter is filtered through Whatman No. 12 folded-filter paper. The filter paper, containing the suspended solids, is ashed in a muffle furnace at 600-degrees centigrade. The residue is transferred to a tared planchet, dried, weighed, and submitted for counting of gross alpha and gross beta radioactivity. The filtrate is evaporated to determine the gross alpha and gross beta radioactivity of the dissolved solids.

The alpha and beta radioactivity counting system is a low background, thin-window, gas-flow proportional counter utilizing a 2-¼ inch detector. Except in the case of ground water, a strontium–89 and strontium–90 determination is made on water samples when the gross beta radioactivity exceeds 5 pCi/liter. If gross beta radioactivity above 5 pCi/liter is detected in a ground water sample, it is analyzed by gamma-ray spectroscopy for radium.

Discussion

All results may be interpreted on the basis of the PHS Drinking Water Standards (*1*), which state that in the absence of strontium–90 and alpha-particle emitters, a water supply is acceptable if the gross beta radioactivity does not exceed 1,000 picocuries per liter of water. This value relates to average intake from water over a long period of time and not for transient conditions.

Table 1 gives the gross alpha radioactivity in raw and treated surface waters as well as maximum and minimum values recorded during 1967. The first column consists of code numbers which indicate the geographical positions of the sampling stations as shown in figure 1. Gross alpha radioactivity was somewhat greater in raw water than in treated water at most stations.

Table 2 gives the average gross beta radioactivity in raw and treated surface waters as well as maximum and minimum values. Maximum beta radioactivity values were detected almost equally between raw and treated water. Locations for sampling gross alpha and beta radioactivity in surface waters are spread across North Carolina in the Mountain, Piedmont, and Coastal regions. Table 3 gives the gross beta radioactivity in North Carolina ground waters.

Table 1. Gross alpha radioactivity found in surface waters used as sources of public water supplies in North Carolina, 1967

Code	Location	Source of water supply	Raw water (pCi/liter)				Treated water (pCi/liter)			
			No. of samples	Average	Maximum	Minimum	No. of samples	Average	Maximum	Minimum
1	Asheville	Bee Tree Creek	6	0.19	0.58	0.02	6	0.03	0.05	0.02
2	Charlotte	Catawba River	7	.15	.45	.00	7	.02	.03	.00
3	Greenville	Tar River	7	.56	1.34	.07	7	.20	.62	.04
4	Hickory	Catawba River	7	.15	.18	.02	6	.11	.30	.02
5	Lillington	Cape Fear River	5	.81	1.97	.02	4	.07	.18	.02
6	Smithfield	Neuse River	7	.36	.70	.10	7	.06	.17	.00
7	Wilmington	Cape Fear River	8	.23	.56	.08	8	.21	.80	.00
8	Winston-Salem	Yadkin River	7	.44	1.25	.12	7	.17	.79	.02

Table 2. Gross beta radioactivity found in surface waters used as sources of public water supplies in North Carolina, 1967

Code	Location	Source of water supply	Raw water (pCi/liter)				Treated water (pCi/liter)			
			No. of samples	Average	Maximum	Minimum	No. of samples	Average	Maximum	Minimum
1	Asheville	Bee Tree Creek	6	3.14	6.59	0.95	6	3.00	8.11	1.14
2	Charlotte	Catawba River	7	2.65	4.81	.86	7	3.13	7.66	1.24
3	Greenville	Tar River	7	4.47	10.72	1.78	7	4.75	8.08	3.02
4	Hickory	Catawba River	7	2.84	5.04	1.91	7	3.99	9.77	1.61
5	Lillington	Cape Fear River	5	5.50	6.11	4.53	4	5.79	9.42	3.69
6	Smithfield	Neuse River	7	5.67	6.09	2.44	7	5.31	8.76	2.94
7	Wilmington	Cape Fear River	8	9.45	50.26	1.92	8	3.43	3.98	2.90
8	Winston-Salem	Yadkin River	7	5.74	21.94	1.74	7	2.21	2.79	1.83

Table 3. Gross beta radioactivity in ground water in North Carolina, 1967

Code	Location	Beta radioactivity (pCi/liter)			
		No. of samples	Average	Maximum	Minimum
9	Broadway	4	4.07	4.60	3.08
10	Clinton	4	7.56	8.80	6.42
11	Gibsonville	4	1.73	2.77	.81
12	Kinston	4	10.41	12.77	8.22
13	Springhope	5	1.45	1.82	1.13
14	Whiteville	3	6.25	7.22	4.41
15	Windsor	5	8.03	9.17	6.75

On some of the islands situated along the eastern seaboard of North Carolina, and at some private residences in Durham County, drinking water is obtained from small cistern water supplies. The cistern supplies are characteristically constructed with roof prewash valves which permit the diversion of the first runoff and then allow the balance of the rainwater to pass into the cistern. Table 4 presents the results for samples taken on Ocracoke Island and in Durham County.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking Water Standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 4. Gross alpha and beta radioactivity in cistern water in North Carolina, 1967

Code	Location	Gross alpha radioactivity (pCi/liter)				Gross beta radioactivity (pCi/liter)			
		No. of samples	Average	Maximum	Minimum	No. of samples	Average	Maximum	Minimum
16	Durham County	1	0.45			1	5.54		
17	Ocracoke Island	14	.41	1.40	0.02	14	6.80	19.83	1.07

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthiy and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network
January 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform field estimates on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during January 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

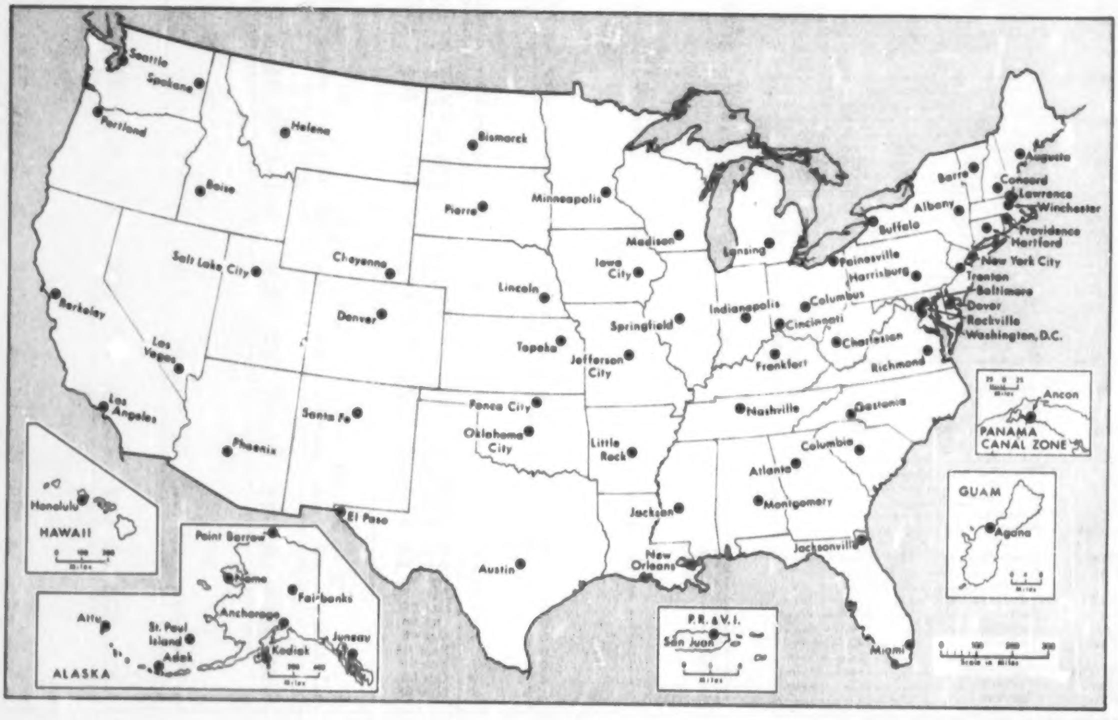
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Iowa City
Madison
Lansing
Berkeley
Denver
Topeka
Springfield
Indianapolis
Columbus
Cincinnati
Jefferson City
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Frankfort
Charleston
Richmond
Painesville
Harrisburg
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan
HAWAII
Honolulu
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
0 100 200 300
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, January 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Number of samples	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	22	6	0	2	Sept 68	3	42	3	42	3
Alaska:	Adak	26	2	1	2	Apr 68	(c)				
	Anchorage	4	0	0	0	Oct 68	(c)				
	Attu Island	21	0	0	0	Mar 69	(c)				
	Fairbanks	(b)				Nov 68	(c)				
	Juneau	19	0	0	0	Dec 68	5	23	5	23	0
	Kodiak	18	1	0	0	Jan 69	(c)				
	Nome	(b)				May 69	(c)				
	Point Barrow	25	0	0	0	Apr 69	(c)				
	St. Paul Island	21	1	1	1	Aug 68	(c)				
Ariz:	Phoenix	21	17	0	6	Dec 68	(c)				
Ark:	Little Rock	6	2	0	1	Oct 68	(c)				
Calif:	Berkeley	22	2	0	0	Jan 69	9	167	9	167	0
	Los Angeles	(b)				May 69	(c)				
C.Z:	Ancon	17	0	0	0	Jan 69	(c)				
Colo:	Denver	23	7	1	2	Jan 69	(c)				
Conn:	Hartford	23	1	0	0	Nov 68	6	26	6	26	0
Del:	Dover	21	1	0	0	Sept 68	(c)				
D.C.:	Washington	(b)				Apr 69	(c)				
Fla:	Jacksonville	19	2	0	1	Oct 68	3	40	3	40	18
	Miami	17	1	0	0	Nov 68	4	129	4	120	0
Ga:	Atlanta	22	2	1	1	Aug 68	3	87	3	87	83
Guam:	Agana	(b)				Sept 68	(c)				
Hawaii:	Honolulu	30	1	0	1	Mar 69	6	141	(d)		
Idaho:	Boise	15	1	0	0	Mar 69	10	73	7	66	8
Ill:	Springfield	22	1	0	0	Apr 69	(c)				
Ind:	Indianapolis	21	1	0	1	Aug 68	9	148	9	148	179
Iowa:	Iowa City	22	0	0	0	Jan 69	(c)				
Kans:	Topeka	22	1	0	0	Oct 68	4	9	4	9	1
Ky:	Frankfort	11	1	0	1	Apr 69	(c)				
La:	New Orleans	20	1	0	0	Apr 69	3	52	(d)		
Maine:	Augusta	9	2	0	1	May 69	6	82	4	64	0
Md:	Baltimore	23	1	0	0	Nov 68	5	35	5	35	15
	Rockville	10	0	0	0	Mar 69	(c)				
Mass:	Lawrence	21	0	0	0	Jan 69	2	32	2	32	9
	Winchester	22	1	0	0	Feb 69	6	54	6	54	0
Mich:	Lansing	12	5	0	2	Mar 69	(c)				
Minn:	Minneapolis	22	1	0	0	Sept 68	9	43	9	43	2
Miss:	Jackson	19	2	0	0	May 69	1	6	1	6	8
Mo:	Jefferson City	21	1	0	0	Aug 68	7	113	7	113	0
Mont:	Helena	21	4	0	1	Feb 69	10	20	10	20	26
Nebr:	Lincoln	22	2	0	0	Aug 68	(c)				
Nev:	Las Vegas	21	2	0	1	Nov 68	(c)				
N.H.:	Concord	22	1	0	0	Apr 69	(c)				
N.J:	Trenton	21	1	0	0	May 69	4	54	4	54	29
N. Mex:	Santa Fe	16	1	0	1	Feb 69	3	11	3	11	6
N.Y:	Albany	19	1	0	1	Aug 68	7	37	7	37	39
	Buffalo	22	1	0	0	Jan 69	(c)				
	New York City	21	2	0	0	Feb 69	(c)				
N.C:	Gastonia	17	13	1	4	Jan 69	3	21	(d)		
N. Dak:	Bismarck	23	0	0	0	Apr 69	9	19	9	19	0
Ohio:	Cincinnati	(b)				Sept 68	(c)				
	Columbus	20	1	0	0	May 69	7	85	7	85	0
	Painesville	23	1	0	1	Nov 68	8	12	8	12	6
Okla:	Oklahoma City	20	2	0	1	Mar 69	1	6	1	6	0
	Ponca City	22	2	0	1	Nov 68	4	15	4	15	0
Ore:	Portland	21	2	0	0	Aug 68	15	130	15	130	28
Pa:	Harrisburg	19	1	0	0	Aug 68	(c)				
P.R:	San Juan	(b)				May 69	(c)				
R.I:	Providence	19	2	0	0	Mar 69	2	30	2	30	13
S.C:	Columbia	12	2	0	0	Feb 69	2	70	2	70	40
S. Dak:	Pierre	19	2	0	1	Dec 68	(c)				
Tenn:	Nashville	17	1	0	0	Mar 69	10	89	10	89	5
Tex:	Austin	22	8	1	4	Sept 68	1	5	(d)		
	El Paso	19	9	1	4	Apr 69	(c)				
Utah:	Salt Lake City	31	1	0	0	May 69	8	35	8	35	5
Vt:	Barre	19	1	0	1	Oct 68	8	39	8	39	0
Va:	Richmond	15	1	0	0	Oct 68	1	10	1	10	1
Wash:	Seattle	25	1	0	0	Oct 68	13	80	(d)		
	Spokane	19	0	0	0	Sept 68	2	8	2	8	3
W. Va:	Charleston	21	1	0	1	Feb 69	10	31	10	31	6
Wis:	Madison	21	1	0	0	Oct 68	11	51	10	49	57
Wyo:	Cheyenne	21	4	1	2	Nov 68	2	5	2	5	9
Network summary		1,295	17	0	1		6	52	6	51	16

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

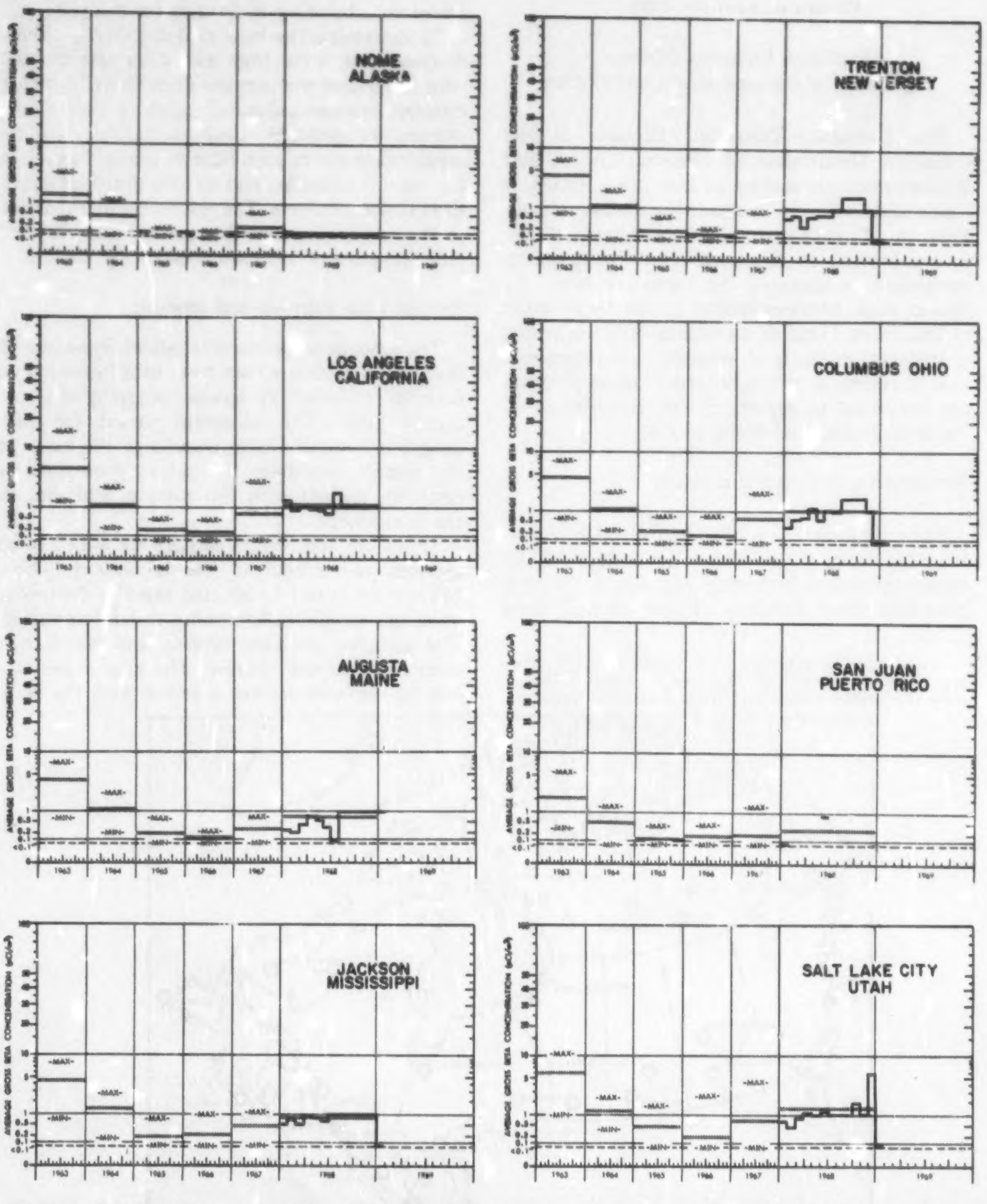

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–January 1969

2. Canadian Air and Precipitation Monitoring Program, January 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 3) are located at airports, where the sampling equipment is operated by personnel from the Meteorologic Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650-cubic meters of air drawn through a high efficiency 4-inch diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa for analysis.

To determine the beta radioactivity, a 2-inch diameter disk is cut from each filter and counted with a thin-end window, gas flow, Geiger–Mueller counter system calibrated with a strontium–yttrium–90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for January 1969 are presented in table 2.

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is 1 month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples depending upon the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter together with the poly-

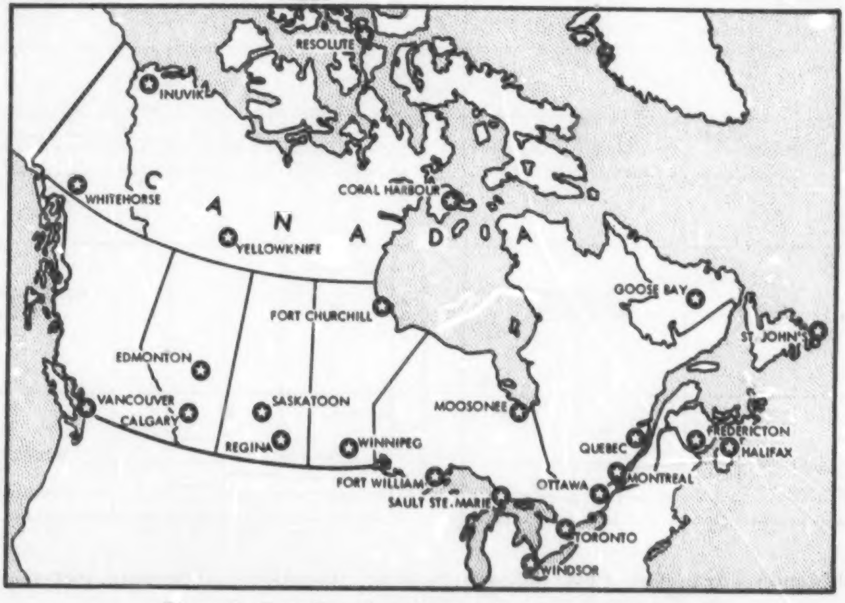

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from February 1969 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

ethylene liner is then ignited and ashed at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp, and then counted with a thin-end window Geiger–Mueller counter calibrated with a strontium–yttrium–90 source.

The monthly precipitation samples represent the total deposition of radioactive materials on the earth's surface. The January 1969 gross beta deposition values are given in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, January 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.2	0.0	0.1	NA	NA
Coral Harbour	31	.1	.0	.1		
Edmonton	31	.1	.0	.1		
Ft. Churchill	31	.1	.0	.0		
Ft. William	31	.1	.0	.1		
Fredericton	31	.1	.0	.0		
Goose Bay	31	.1	.0	.0		
Halifax	31	.1	.0	.0		
Inuvik	31	.1	.0	.0		
Montreal	29	.2	.0	.0		
Moosonee	30	.1	.0	.0		
Ottawa	31	.1	.0	.1		
Quebec	31	.1	.0	.0		
Regina	30	.1	.0	.1		
Resolute	30	.1	.0	.1		
St. John's, Nfld	30	.1	.0	.0		
Saskatoon	31	.1	.0	.1		
Saulte Ste. Marie	19	.1	.0	.1		
Toronto	30	.1	.0	.1		
Vancouver	31	.1	.0	.1		
Whitehorse	31	.1	.0	.1		
Windsor	31	.2	.0	.1		
Winnipeg	31	.1	.0	.1		
Yellowknife	31	.1	.0	.1		
Network summary	725	0.2	0.0	0.1	NA	NA

NA, no analysis reported.

3. Pan American Air Sampling Program January 1969

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The January 1969 air monitoring results from the participating countries are given in table 3.

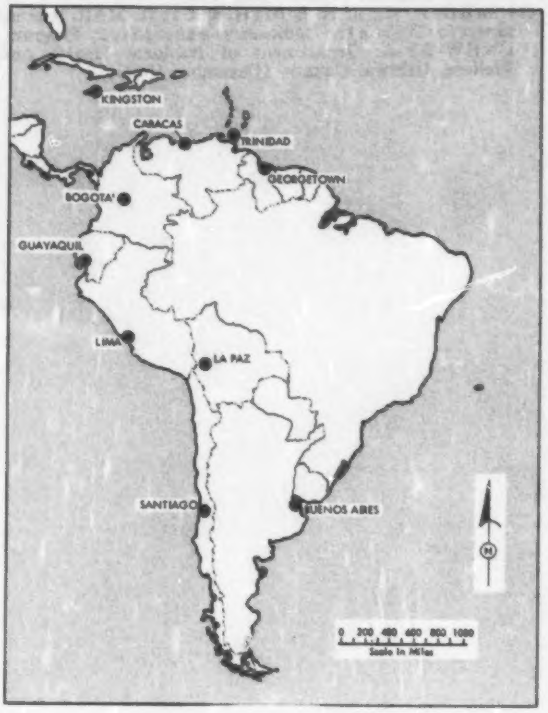

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, January 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	NS			
Bolivia:	La Paz	19	0.26	0.01	0.08
Chile:	Santiago	31	.33	.06	.21
Colombia:	Bogata	9	.03	.01	.02
Ecuador:	Guayaquil	21	.27	.08	.15
Guyana:	Georgetown	18	.08	.00	.03
Jamaica:	Kingston	22	.11	.01	.03
Lima:	Peru	NS			
Venezuela:	Caracas	20	.05	.00	.03
West Indies:	Trinidad	18	.05	.01	.02
Pan American summary		158	0.33	0.00	0.00

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no samples.

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(*1*) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. Bureau of Radiological Health, Office of Standards and Criteria, Rockville, Md. 20852 (Distribution by official request).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*4*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*5*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*6*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site January-June 1965

Southwestern Radiological Health Laboratory, DHEW, and
Nevada Operations Office, AEC

Under a memorandum of understanding between the U.S. Atomic Energy Commission and the Public Health Service, DHEW, the Southwestern Radiological Health Laboratory (SWRHL) of the Bureau of Radiological Health, performed radiological surveillance in the public areas surrounding the Nevada Test Site (NTS) during the period, January through June 1965. During this period, 17 announced underground nuclear tests were conducted at the NTS and five reactor experiments were conducted at the Nuclear Rocket Development Station (NRDS), a part of the NTS complex.

Operational procedures

Both ground and aerial monitoring capabilities were maintained throughout this period. Mobile ground monitoring teams were positioned in offsite areas prior to each test, and an aerial monitoring team was prepared to track any radioactive releases to determine relative radiation intensities and to indicate cloud position, speed, and direction. Monitoring teams were equipped with Eberline E–500B, Precision Model 111 Standard "Scintillator," and Victoreen Radector Model No. AGB–50B–SR portable survey instruments. Eberline RM–11 gamma ray, exposure-rate recorders were also utilized to document cloud passage at fixed ground locations.

The SWRHL environmental surveillance program collected air, milk, water, and vegetation samples. Two C–45 aircraft were used as necessary for radioactive cloud sampling by cryogenic, electrostatic precipitator, and mass air sampling techniques. The SWRHL Air Surveillance Network (ASN) expanded from 59 to 97 stations during this period, has given coverage to every State west of the Mississippi River except Montana and North Dakota (figures 1 and 2). The air sampler used in the ASN was a Gelman "Tempest" equipped to use a 4-inch diameter Whatman-541 filter paper and an MSA charcoal cartridge. The established milk sampling program from both commercial dairies and private producers continued throughout the 6-month period. A total of 136 routine milk samples were collected from 31 sources. Water samples were also collected on a routine basis from both potable and nonpotable supplies. A total of 170 water samples were col-

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[1] This article is a summary of report No. SWRHL–23r, Offsite Surveillance Activities of the Southwestern Radiological Health Laboratory from January through June 1965 (July 1, 1966) by the Southwestern Radiological Health Laboratory, Las Vegas, Nev.

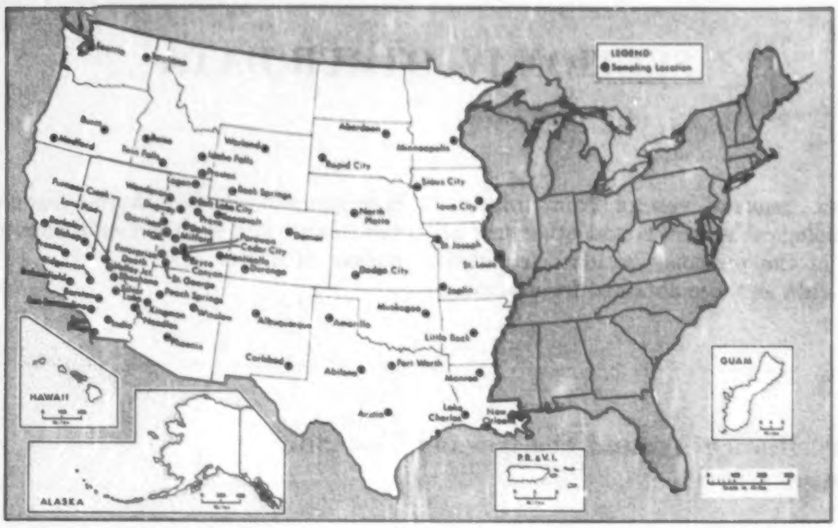
LEGEND
Sampling Location
Aberdeen
Minneapolis
Rapid City
Sioux City
Iowa City
North Platte
Denver
St. Joseph
St. Louis
Dodge City
Joplin
Muskogee
Amarillo
Albuquerque
Little Rock
Fort Worth
Carlsbad
Abilene
Monroe
Austin
Lake Charles
New Orleans
Boise
Idaho Falls
Rock Springs
Salt Lake City
Logan
Durango
Phoenix
HAWAII
ALASKA
GUAM
P.R.&V.I.

Figure 1. Air surveillance network stations other than Nevada

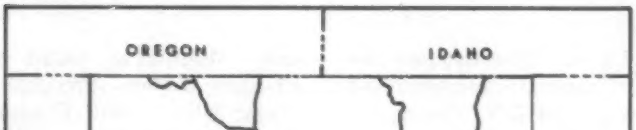
OREGON
IDAHO
UTAH
CALIFORNIA
ARIZONA
WELLS
ELKO
BATTLE MOUNTAIN
WINNEMUCCA
LOVELOCK
FALLON
AUSTIN
EUREKA
ELY
TONOPAH
GOLDFIELD
SCOTTY'S JCT
BEATTY
CALIENTE
PIOCHE
ALAMO
LAS VEGAS
0 25 50 75 100 Miles

Figure 2. Air surveillance network stations in Nevada

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lected from 39 sources. Milk and water samples were normally collected on a monthly basis unless special sample collection was indicated (figure 3 shows routine milk and water sampling locations). Vegetation samples, the results of which are used to delineate any fallout pattern, were collected only after a known release of radioactivity.

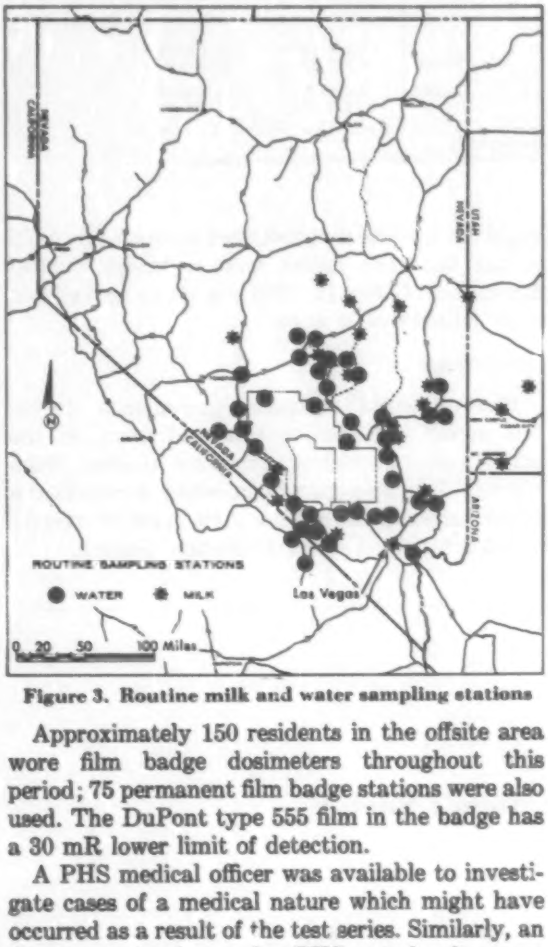

Figure 3. Routine milk and water sampling stations

Approximately 150 residents in the offsite area wore film badge dosimeters throughout this period; 75 permanent film badge stations were also used. The DuPont type 555 film in the badge has a 30 mR lower limit of detection.

A PHS medical officer was available to investigate cases of a medical nature which might have occurred as a result of the test series. Similarly, an Army veterinarian and a PHS veterinarian were available to conduct wildlife or domestic livestock investigations.

Analytical procedures

Samples were returned to the SWRHL in Las Vegas for radiological analysis. Air sample particulate filters were counted for beta radioactivity in a Beckman wide beta low-background, proportional counter system. Selected particulate filters, all charcoal cartridges, water, and milk samples were analyzed for gamma ray emitting isotopes using a 4-inch by 4-inch NaI (T1) crystal coupled to a TMC Model 404C gamma-ray pulse height analyzer. The lower limit of detection for gamma-ray emitters in milk samples was 20 pCi/liter at the time of count. Gamma-ray spectra were evaluated using a matrix technique which allowed for the simultaneous determination of eight nuclides.

Results

Four underground tests released radioactive effluent which was detected in offsite populated areas. These were the Alpaca event on February 12; the Project Palanquin, a Plowshare cratering experiment, on April 14; the Tee event on May 7; and the Diluted Waters event on June 16, 1965. In addition, five reactor experiments conducted at the NRDS also released radioactive effluent to the offsite environment. These were the Kiwi Transient Nuclear Test (TNT) on January 12; the NRX–A3 Experimental Plans 4, 5, and 6 on April 23, May 20, and May 28; and the Phoebus 1A on June 25, 1965. The highest levels of radioactivity detected offsite are shown in tables 1 to 3.

Table 1. Highest levels of radioactivity in off-NTS areas January–June 1965

Date (1965)	Highest ground monitoring results from different events	
	Location	Net gamma radioactivity reading (mR/hr)
January 12	1.5 miles west of Lathrop Wells, Nev. (unpopulated)	70
April 14	Stone Cabin Ranch, Warm Springs, Nev.	3
June 25	Queen City Summit, Nev. (unpopulated)	0.061

The highest concentration of fresh fission products found in a potable water sample was 70 pCi/liter of iodine–131 found in tap water collected on April 18, 1965, near Warm Springs, Nev. The only film badges indicating positive exposures were the permanent station badges collected following the Project Palanquin. The maximum exposure on any badge was 45 mR at the Stone Cabin Ranch near Warm Springs, Nev., exposed from March 31, 1965 to May 6, 1965. Selected offsite residents from the downwind area were brought to the SWRHL for whole body counting following the Project Palanquin. The maximum measured thyroid exposure was 160 mrad. It should be noted that the radioactivity in many of the samples collected during this 6-month period

Table 2. Highest levels of air sampling results in off-NTS areas (based on iodine-131) January–June 1965

Date (1965)	Location	Gross beta radioactivity (pCi/m³)	Radionuclide analysis (pCi/m³)	
			Iodine-131	Iodine-133
January 12 (1045–1230 hrs)	Hwy. 95, 1.5 miles west of Lathrop Wells, Nev. (unpopulated)	210,000	[a] 630 (F) [b] 150 (C)	13,000 (F) 290 (C)
April 14 (1115–1235 hrs)	Hwy. 6, 8-miles east of Tonopah Test Range, Nev. (unpopulated)	87,000	8,200 (F) 4,200 (C)	33,000 (F) 32,000 (C)
April 14 (0412–1615 hrs)	Clark Station, Nev	23,000	3,400 (F) 670 (C)	10,000 (F) 6,100 (C)

[a] F–Whatman-541 particulate filter to collect particulate fission products.
[b] C–MSA charcoal cartridge, secondary to particulate filter, for collection of radioactive gases, primarily iodine.

Table 3. Highest levels of milk sample results in off-NTS areas, January–June 1965

Date (1965)	Location	Iodine-131 concentration (pCi/liter)
April 18	Martin Ranch, Eureka, Nev.	11,000
April 19	Martin Ranch, Eureka, Nev.	11,000
April 20	Pasquale-Richards Ranch, Paradise Valley, Nev.	5,500 (highest value found at farm where children were living).

[a] These concentrations are peak levels that occurred a few days after the event. The radioactivity levels returned to <20 pCi/liter within a month.

could not be directly attributed to any single NTS release and that fallout from a foreign nuclear detonation of May 14, 1965 was also observed in a large number of samples.

Conclusions

Environmental radiation surveillance during this period indicates that no individual in the offsite area received an exposure resulting from Nevada Test Site operations, which exceeded the guides established by the AEC and/or recommended by the Federal Radiation Council.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Argonne National Laboratory, the Neutron Devices Department (formerly known as the Pinellas Peninsula Plant) and the Mound Laboratory.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory[2]
January–June 1968

University of Chicago
Lemont, Illinois

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. The alpha and beta radioactivity in air-filter samples are summarized in table 1. The alpha radioactivity concentrations were normal both on and off the site and in the range found in previous years. As in the past, much of the beta and gamma radioactivity was due to fission and neutron activation products from nuclear detonations, although about one-third of the gamma radioactivity and a smaller fraction of the beta radioactivity was due to beryllium–7, produced continuously in the upper atmosphere by cosmic-ray interactions. The variation in total beta radioactivity during the year can be correlated with the concentrations of the individual gamma-ray emitters. An increase by a factor of three from December 1967 to January 1968, was due to an increase in the amounts of

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[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, January–June 1968," University of Chicago, Lemont, Ill.

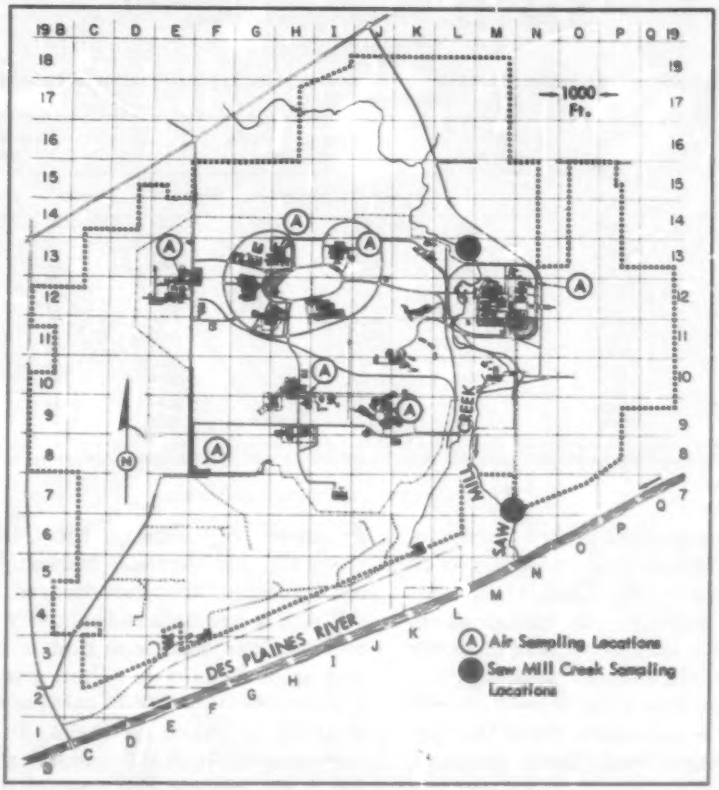

Figure 1. Sampling locations on the site of Argonne National Laboratory

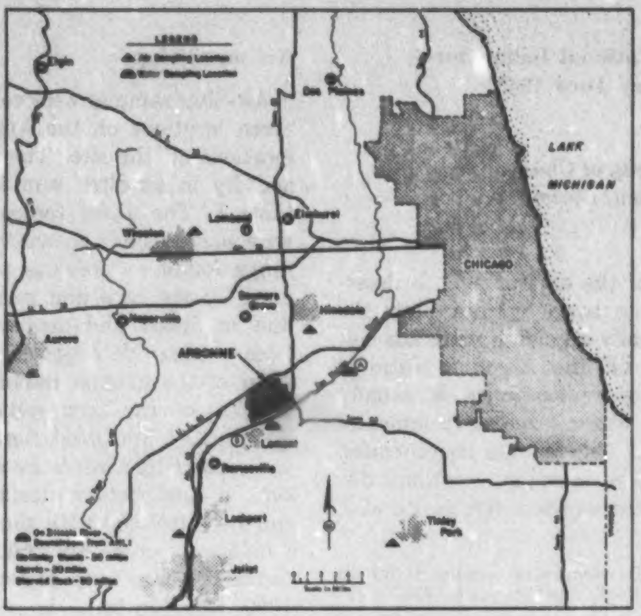

Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

Table 1. Alpha and beta radioactivity in air-filter samples, Argonne National Laboratory January–June 1968[a]

Date (1968)	Location	Number of samples	Alpha radioactivity (pCi/m³)			Beta radioactivity (pCi/m³)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Onsite	26	0.0039	0.0019	0.0061	0.16	0.08	0.33
	Offsite	23	.0049	.0025	.0082	.16	.08	.25
February	Onsite	24	.0042	.0027	.0062	.23	.10	.49
	Offsite	20	.0043	.0008	.0062	.24	.14	.38
March	Onsite	26	.0051	.0019	.0101	.28	.19	.49
	Offsite	22	.0051	.0027	.0092	.32	.21	.51
April	Onsite	27	.0045	.0024	.0073	.29	.19	.51
	Offsite	23	.0053	.0030	.0080	.29	.13	.46
May	Onsite	26	.0047	.0030	.0081	.24	.14	.34
	Offsite	22	.0050	.0017	.0111	.24	.14	.36
June	Onsite	24	.0046	.0023	.0084	.25	.11	.38
	Offsite	20	.0060	.0014	.0126	.26	.11	.41
Summary	Onsite	153	0.0045	0.0019	0.0101	0.24	0.08	0.51
	Offsite	130	0.0051	0.0008	0.0126	0.25	0.08	0.51

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioacticity due to radon and thoron decay products.

the short- and medium-lived fission products, such as barium–lathanum–140, zirconium–niobium–95, and ruthenium–103. Much of the zirconium–niobium–95 activity was contained in discrete, insoluble particles. The beta radioactivity reached a maximum in March and April 1968, when the zirconium–niobium–95 and beryllium–7 concentrations were also at a maximum. Since the concentrations of the longer-lived fission products, cerium–144 and ruthenium–rhodium–106, did not decrease from March to June and the beryllium–7 decreased only slightly, the total beta radioactivity did not decrease markedly as the barium and zirconium activities decayed.

The average beta radioactivity during January to June 1968 was twice that of the 1967 annual average and about one-third greater than during January to June 1967, because of the increased quantity of fission products. In particular, the zirconium–niobium–95 concentration was about ten times greater this year than in 1967. Precipitation was also collected and analyzed for fission products, and the same radioisotopes found in the air-filter samples were also present. The shorter-lived fission products, for example, were present in precipitation only early in the year.

Sampling on charcoal, specifically for gaseous radioiodine, was conducted continuously on the site. No activity above the minimum detectable concentration of 0.1 pCi/m^3 was detected during this time period.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500-yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the radioactivity in the creek. The sampling locations are shown in figure 2.

Below the wastewater outfall the creek was usually sampled three times weekly. Since it was impractical to analyze all the samples for all the nuclides and elements desired, equal portions of the three samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected at weekly intervals, and at least one sample each month was analyzed for each radioactive nuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during January–June 1968 are given in table 2.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in the creek water due to these elements are summarized in table 3. The average uranium concentrations below the outfall was about 2.4 pCi/liter, while the plutonium and thorium concentrations averaged less than the minimum detectable amount.

In addition to the natural beta radioactivity in the creek, beta radioactivity from fallout was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. The Argonne contribution to the total beta radioactivity below the outfall during the first half of 1968 is estimated to be approximately 20 pCi/liter, compared to 10 pCi/liter in 1967. The concentration of fallout radioactivity was about twice that during 1967.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled monthly above the mouth of Sawmill Creek and weekly below the mouth to determine if the radioactivity in the creek had any effect on the radioactivity in the river. The total radioactivity is summarized in table 4. The average concentrations were very similar at both locations, indicating that Sawmill Creek water had no significant effect on the radioactivity in the river. The alpha radioactivity was normal and similar to that found in pre-

Table 2. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne, January–June 1968

Date (1968)	Location [a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Upstream	2	4.0	3.5	4.5	11	8.8	13
	Downstream	12	1.6	0.9	3.3	31	11	50
February	Upstream	2	3.0	2.4	3.6	10	9.1	11
	Downstream	12	2.9	2.1	4.4	32	15	45
March	Upstream	2	3.7	3.3	4.1	10	9.6	11
	Downstream	15	4.2	1.7	9.9	15	13	20
April	Upstream	2	3.6	2.8	4.3	21	8.7	33
	Downstream	12	2.2	1.3	3.2	39	15	93
May	Upstream	2	2.2	2.0	2.3	14	11	17
	Downstream	15	3.6	1.6	9.6	34	15	75
June	Upstream	2	2.2	1.9	2.5	18	16	20
	Downstream	12	2.1	2.0	2.4	27	14	56
Summary	Upstream	12	3.1	1.9	4.5	14	8.7	33
	Downstream	78	2.8	0.9	9.9	30	11	93

[a] Relative sampling location with respect to Argonne waste water outfall (figure 1).

Table 3. Alpha-emitting elements in Sawmill Creek water, Argonne
January–June 1968

Element	Location [a]	Number of samples	Concentration (pCi/liter)			Average as a percent of AEC standard
			Average	Minimum	Maximum	
Uranium	Upstream	6	2.0	1.2	2.8	0.005
	Downstream	26	3.4	1.2	12.0	.009
Plutonium	Upstream	6	----------	----------	<0.05	----------
	Downstream	12	<0.05	<0.05	.18	<0.001
Thorium	Upstream	6	----------	----------	<0.05	----------
	Downstream	12	----------	----------	<0.05	----------

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

Table 4. Average radioactivity in Des Plaines and Illinois River water, Argonne, January–June 1968

Location	Concentration (pCi/liter)	
	Non-volatile alpha radioactivity	Non-volatile beta radioactivity
Des Plaines River [a] (above Sawmill Creek)	4.4	13
Des Plaines River [b] (below Sawmill Creek)	3.8	15
Illinois River [c]	2.9	8

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.

[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.

[c] Average for samples collected at three locations (McKinley Woods State Park, Morris, and Starved Rock State Park) on May 12, 1968.

vious years. The average beta radioactivity was about equally divided between fallout and natural radioactivity.

The Illinois River was sampled at McKinley Woods on June 6 and the total radioactivity in these samples was similar to those found in other bodies of water in the area and to the radioactivity found previously at these same locations.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Strontium-89, iodine-131, and barium-140, were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine-131 and 3 pCi/liter for the other two radionuclides. The strontium-90 and cesium-137 concentrations are given in table 5. These two radionuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The cesium-137 concentrations during this period decreased to less than one-half of the 1967 concentrations, while the strontium-90 concentrations were nearly the same. Iodine-131 and barium-140 were not detected during this period.

Table 5. Fission product concentrations in milk
January–June 1968

Date collected (1968)	Cesium-137 (pCi/liter)	Strontium-90 (pCi/liter)
January 3	30	5.8
February 7	30	5.8
March 6	35	7.7
April 4	30	8.8
May 2	40	8.6
June 5	60	7.0
Average	39	7.3

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	March 1968
July–December 1967	August 1968

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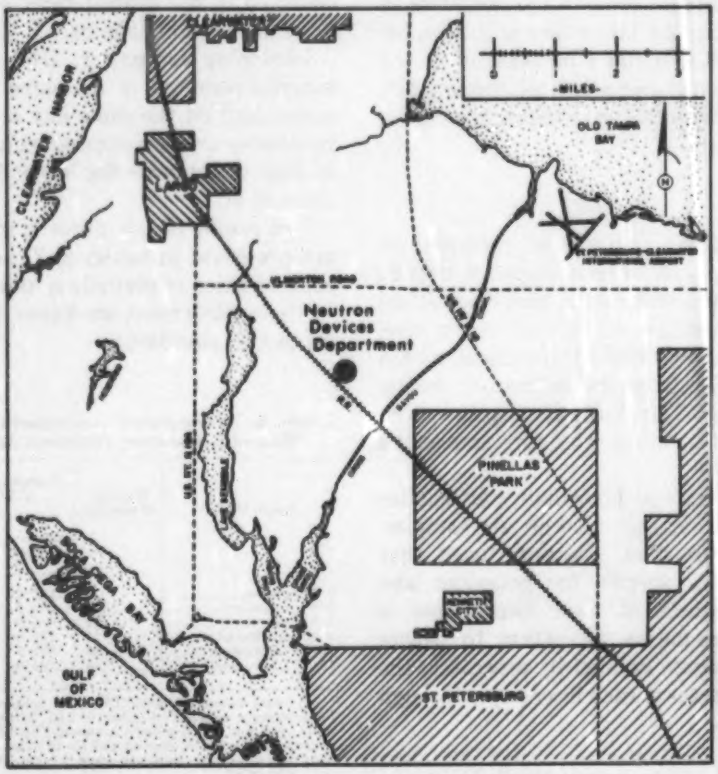
2. Neutron Devices Department[3]
July–December 1967

General Electric Company
St. Petersburg, Fla.

The Neutron Devices Department, shown in figure 3 is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plants's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous nonoccupational exposure established by AEC and documented in the "AEC Manual."

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period 4 of 205 samples analyzed showed detectable concentrations of tritium (300 nCi/liter).[4] The maximum concentration, 1,300 nCi/liter, which was detected on July 27, 1967, amounted to 43 percent of the continuous nonoccupational exposure guide. Calculations based on radioactivity releases from the process waste system, and the plant's water discharges, indicate that the average tritium concentration in the combined sewer effluent for July–December 1967 was less than 1.2 percent of the AEC Radiation Protection Standard for continuous nonoccupational exposure.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ULMERTON ROAD
Neutron
Devices
Department
R.R.
U.S. RT. 19
PINELLAS PARK
BOCA CIEGA BAY
KENNETH CITY
GULF OF MEXICO
ST. PETERSBURG

Figure 3. Location of the Neutron Devices Department

---

[3] Summarized from "Environmental Monitoring, July 1 through December 31, 1967" General Electric Company, Neutron Devices Department, St. Petersburg, Fla., formerly known as the Pinellas Peninsula Plant.

[4] Expressions in parentheses indicate limits of detectability in the respective environmental samples.

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Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium oxide (90 nCi/liter) in the 61 surface water samples analyzed during the sampling period.

Milk sampling results

Seventeen samples of raw milk were collected from local dairy farms and analyzed by the Florida State Board of Health during the second half of 1967. No detectable concentrations (90 nCi/liter) of tritium were evident.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	July 1967
January–June 1967	February 1968

3. Mound Laboratory[5]
January–June 1968

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specific for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and hydrogen-3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air in the network of 111 locations within a radius of 20 miles from the laboratory during the collection period. The choice of sites on a given day was dependent upon the wind direction at the time of collection.

Airborne polonium and plutonium particulates are collected with a high-volume air sampler. The filter paper are then processed such that counting results are specific for polonium and plutonium. One fourth of each filter paper is processed by spontaneous deposition to isolate polonium. Plutonium is isolated by processing the remaining three fourths of each filter paper through a resin column.

Airborne tritium is monitored by drawing air through a calcium chloride drying tube. The water collected in the sample tube is distilled and analyzed for tritium content.

Beginning January 1, 1967, all particulate air samples collected in the same zone, in the same range, and on the same day are combined before processing and are considered as one sample. This is done to improve the lower detectable limit for plutonium.

The results of the airborne monitoring program are presented in tables 6, 7, and 8. The average concentration of plutonium, polonium, and tritium in the environment are below the AEC radiation protection standards.

Table 6. Atmospheric monitoring of polonium-210 Mound Laboratory environs, January–June 1968

Range (miles)	Number of samples	Concentration[a] (fCi/m^3)		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	24	440.2	43.0	0.21
0–3 (downwind)	24	404.2	45.4	.23
3–5 (downwind)	24	396.6	44.1	.22
5–10 (downwind)	24	331.5	37.9	.19
10–15 (downwind)	24	312.7	37.5	.19
15–20 (downwind)	24	236.8	28.3	.14

[a] Lowest detectable level (LDL) for polonium-210 in air is 8.0 fCi/m^3 for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5.3 fCi/m^3 for samples collected 0–3 miles downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for polonium-210 in air is 20,000 fCi/m^3.

---

[5] Summarized from "Environmental Monitoring Report January–June 1968" (MLM-1522).

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Table 7. Atmospheric monitoring of plutonium-238 Mound Laboratory environs, January–June 1968

Range (miles)	Number of samples	Concentration ᵃ (fCi/m³)		Average as percent of AEC standards ᵇ
		Maximum	Average	
0–3 (upwind)	24	37.9	14.6	20.86
0–3 (downwind)	24	36.5	10.9	15.57
3–5 (downwind)	24	81.1	16.5	23.57
5–10 (downwind)	23	55.0	16.1	23.00
10–15 (downwind)	23	36.5	14.8	21.14
15–20 (downwind)	23	54.4	11.3	16.14

ᵃ Lowest detectable limit (LDL) for plutonium-238 in air is 1.3 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind and 10–15 miles downwind. The LDL is 0.9 fCi/m³ for samples collected 0–3 downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

ᵇ The applicable AEC radiation protection standard for plutonium-238 in air is 70 fCi/m³.

Table 8. Atmospheric monitoring of tritium, Mound Laboratory environs, January–June 1968

Range (miles)	Number of samples	Concentration ᵃ (fCi/m³)		Average as percent of AEC standards ᵇ
		Maximum	Average	
0–3 (upwind)	23	16.55	4.85	2.42
0–3 (downwind)	23	12.95	3.81	1.90
3–5 (downwind)	23	10.95	3.14	1.57
5–10 (downwind)	23	12.85	3.74	1.87
10–15 (downwind)	23	10.15	3.49	1.74
15–20 (downwind)	23	16.90	4.07	2.03

ᵃ Lowest detectable limit for tritium in air is 2.00 nCi/m³. All values which were not detectable were set equal to this value when average values were calculated.

ᵇ The applicable AEC radiation protection standard for tritium in air is 200 nCi/m³.

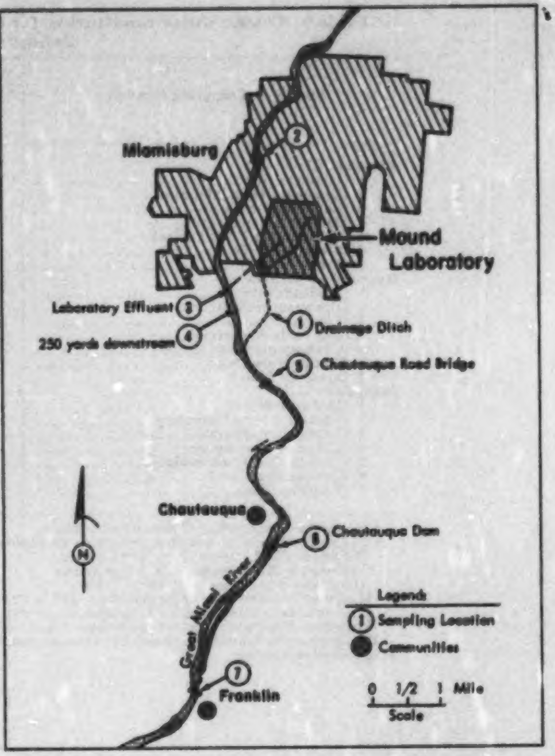

Figure 4. Water sampling locations, Mound Laboratory

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration at which it may be discharged to the Great Miami River.

Helium-3, which is purified at the Mound Laboratory, contains small quantities of hydrogen-3 (tritium). Liquid wastes from this operation are treated separately to assure that the radioactivity level is below the AEC radiation protection standard before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and six locations along the Great Miami River as shown in figure 4. Additional samples are taken quarterly at more distant downstream points. The drainage ditch carries all storm sewer water and treated liquid tritium and plutonium wastes from the plant site. Sampling location number 3 (figure 4) is the point of discharge of the liquid polonium waste to the Great Miami River, and number 7, at Franklin, Ohio, is 5 miles downstream from the effluent outfall.

All of the river samples are analyzed for polonium-210 and plutonium-238 and some of the samples are analyzed for tritium. The drainage ditch samples are analyzed for tritium and plutonium-238. Average concentrations of tritium, polonium-210, and plutonium-238 are given in table 9 on next page for January–June 1968.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	April 1968
July–December 1967	September 1968

Table 9. Offsite water monitoring for radioactivity, Mound Laboratory environs
January–June 1968

Nuclide and sampling location [a]	Number of samples	Concentration (pCi/liter)	
		Maximum	Average [b]
Polonium–210 [c]			
1 (Drainage ditch)	24	21.62	4.01
2 (Upstream from laboratory)	24	1.80	1.80
3 (Laboratory effluent)	24	1,267.57	118.20
4 (250-yards downstream)	24	19.82	3.34
5 (Chautauqua Road Bridge)	24	5.40	2.02
6 (Chautauqua Dam)	24	1.80	1.80
7 (Franklin, Ohio)	24	1.80	1.80
Hydrogen–3 (tritium) [c]			
1 (Drainage ditch)	23	2.79×10^6	0.52×10^6
2 (Upstream from laboratory)	23	0.16×10^6	$.06 \times 10^6$
3 (Laboratory effluent)	23	1.13×10^6	$.27 \times 10^6$
4 (250-yards downstream)	23	$.19 \times 10^6$	$.06 \times 10^6$
5 (Chautauqua Road Bridge)	23	$.28 \times 10^6$	$.07 \times 10^6$
6 (Chautauqua Dam)	23	$.23 \times 10^6$	$.06 \times 10^6$
7 (Franklin, Ohio)	23	$.30 \times 10^6$	$.07 \times 10^6$
Plutonium–238 [c]			
1 (Drainage ditch)	24	2,454.16	481.14
2 (Upstream from laboratory)	24	15.42	5.95
3 (Laboratory effluent)	23	79.27	18.35
4 (250-yards downstream)	24	36.31	7.72
5 (Chautauqua Road Bridge)	24	10.84	5.75
6 (Chautauqua Dam)	24	8.48	5.10
7 (Franklin, Ohio	24	28.10	6.29

[a] See figure 4 for number of sampling locations.

[b] The applicable AEC radiation protection standards for uncontrolled area are as follows:
Polonium–210 in water: 7×10^2 pCi/liter.
Plutonium–238 in water: 5×10^3 pCi/liter.
Hydrogen–3 in water: 3×10^6 pCi/liter.

[c] Minimum detectable level for polonium–210 in water is 1.80 pCi/liter.
Minimum detectable level for hydrogen–3 in water is 0.05×10^6 pCi/liter.
Minimum detectable level for plutonium–238 in water is 4.50 pCi/liter.
All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

Reported Nuclear Detonations, April 1969

The U.S. Atomic Energy Commission announced that two nuclear tests of low-intermediate yield (20–200 kilotons TNT equivalent) were conducted underground on April 30, 1969 by the Atomic Energy Commission at its Nevada Test Site.

Shortly after the detonations, AEC instruments near ground zero of one of the tests showed some radiation readings slightly above background. It is not expected that any radioactivity will be detected offsite.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIOLOGICAL HEALTH ASPECTS OF SPENT RADON SEEDS.

Richard F. Boggs, Gail D. Schmidt, and Kenneth D. Williams. Radiological Health Data and Reports, Vol. 10, May 1969, pp. 185–190.

Following three incidents of radiation exposure to wearing jewelry contaminated with radioactivity were overexposed, the Bureau of Radiological Health (BRH) examined the early development, the present clinical use, and disposal of gold radon seeds, the suspected source of the contamination. The Ad Hoc committee called by the BRH to study the problem, recommended that (1) the State and local radiological health agencies that have regulatory authority over radon seeds be familiar with the appropriate regulations, (2) that users of radon be advised to keep an account of radon seeds procured, not to supply unused or spent radon seeds to any unauthorized person and to return all decayed or unwanted radon seeds to the supplier or persons authorized to receive such shipments, (3) gold refiners and processors be alerted to the possibility of receiving contaminated gold and efforts should be made to prevent such material from entering the commercial market, (4) the BRH consider the possibility of further investigation of the extent of the problem and consider providing technical assistance through appropriate agencies, and (5) the medical community be encouraged to investigate the feasibility of using other radionuclides for permanent implants.

KEYWORDS: Exposure, gold, lead-210, radon seeds, regulations.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 6, June 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collection, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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Department of Defense
Department of the Interior
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

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Published under the direction of

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Acting Director
Bureau of Radiological Health

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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Environmental Control Administration ● Bureau of Radiological Health

Reports

Preliminary Results of Surveys of 5,263 Medical X-ray Facilities 1962-1967[1]

Bureau of Radiological Health[2]

Preliminary results of State surveys of 5,263 facilities with medical x-ray equipment are presented. Parameters such as equipment type and operating characteristics, personnel protection, workload, and certain aspects of operating technique were studied over a period, from 1962 to 1967. The results of these studies will be considered together with other studies now in preparation, and it is possible that some of the findings will be changed when the data are further evaluated.

As of June 30, 1967, data from surveys of 5,263 facilities with medical x-ray equipment were available for retrieval from magnetic-tape records. These surveys were performed by personnel of 25 States and 2 territories, and covered the period 1967 to 1967. Eight States, 1 territory and the District of Columbia contributed less than 100 surveys each. They are Alaska, Indiana, Iowa, Ohio, Pennsylvania, Utah, Vermont and the Virgin Islands. Seventeen States and 1 territory contributed 100 or more surveys each. They are Alabama, Arkansas, Colorado, Kansas, Kentucky, Maine, Maryland, Massachusetts, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, Oregon, Rhode Island, Washington, and Puerto Rico. The survey data were collected on standardized forms supplied by the Public Health Service. From this information frequency distributions on selected items of interest were produced. The frequency distributions tabulated in this report are designed to permit comparisons between healing arts specialties which provide the largest homogeneous, mutually exclusive subsamples.

Attention is directed to certain aspects of the preliminary findings listed in the tables.

1. The "total" columns do not represent the sums of the numbers given for the specialties listed under type of facility or type of practice. The reason is that many categories provided subsamples that were too small to permit comparison with the larger groups identified in the tables, but still constituted part of the facilities or practices with medical x-ray equipment.

2. In many tables a large percentage of entries are designated "unknown," largely because some participating States do not require the specific items of information to be collected as part of their survey programs.

3. The "card information" reported in the tables refers to the data appearing on the facility form,

---

[1] This report presents preliminary results which, together with findings of other studies currently available to the Bureau of Radiological Health, will be critically reviewed for reporting to Congress under Public Law 90-602, as required, by January 1, 1970. The report to Congress, now in preparation, will critically evaluate the information and it is possible that some of the data will be changed or deleted should analysis of the data indicate that such change or deletion is appropriate, based on statistical or related considerations.

[2] Extracted from Radiation Control for Health and Safety Act of 1967, Hearings before the Committee on Commerce, United States Senate, 90th Congress, 2nd session on S20, 67, S3211, H.R. 10790, Part 2 (May 6, 8, 9, 13, 15, 1968) p. 1075. Prepared by Lawrence R. Fess and Lavert C. Seabron.

the radiographic form, and the fluoroscopic form, making up the X-ray Protection Survey Report. Each form used has a corresponding IBM card. Hence the use in the tables of the term "facility card information", "radiographic card information" etc. A radiographic-fluoroscopic unit will have more than one card, each related to a different use of the machine. Details about the forms and cards have been published (*1*).

This report attempts to provide a systematic approach to the analysis of the data. The effort is to provide: (a) a profile of the "average" medical diagnostic x-ray facility as obtained from the particular sample surveyed—bearing in mind that none of the averages or ratios in any of the columns is typical of the specialties except by chance, and (b) indications of either conformance with, or deviations from, accepted practice with respect to specific items considered in the survey.

Personnel, workload, and equipment. In table 1, data presented by type of practice and type of facility reveal that the number of persons (including those occupationally exposed, x-ray machine operators, and those monitored), as well as the quantity of equipment, is related to patient workload. As expected, the workload is greatest in hospitals, radiologists' offices, and clinics.

Table 1. Personnel, workload, and equipment from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Facility data	Type of facility or type of practice										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Personnel:											
Average number of personnel occupationally exposed	4.3	2.4	2.0	2.1	2.5	1.6	3.4	3.7	5.0	1.2	2.5
Average number of x-ray machine operators	3.7	1.9	1.7	1.8	1.8	1.5	2.6	2.8	4.2	1.1	2.1
Average number of personnel monitored	3.2	.5	.1	.2	.7	.1	.8	1.3	3.9	.1	1.0
Workload: (average number of patients per week per facility)											
Radiographed	143.2	15.4	6.2	17.9	37.1	4.3	31.4	133.3	120.9	4.4	47.4
Fluoroscoped	18.8	5.6	3.3	5.0	8.0	4.2	3.8	12.0	18.0	3.0	11.3
Equipment: (average number per facility)											
X-ray machines	2.0	1.1	1.0	1.0	1.0	1.0	1.1	1.2	3.0	1.0	1.36
X-ray tubes	3.5	1.2	1.0	1.1	1.1	1.1	1.4	1.7	4.4	1.0	1.66
Ratio of tubes to machines	1.70	1.14	1.05	1.12	1.02	1.11	1.29	1.36	1.48	1.00	1.23
Number of facilities	146	280	65	1,508	122	134	200	141	740	904	5,263

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

Table 2. Darkroom procedures from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Facility data	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Darkroom:											
Facilities with no darkroom	2.7	28.2	38.5	16.1	9.0	9.0	8.0	19.2	8.5	16.5	16.0
Darkrooms surveyed that were light-tight	94.7	81.9	92.3	84.0	86.1	89.2	83.7	86.7	89.3	86.4	85.5
Automatic processing used:											
Yes	24.6	.7	.0	.2	3.3	.0	.5	2.8	14.2	.4	3.5
No	58.8	68.6	78.5	85.8	86.9	95.5	92.5	80.1	77.4	79.1	78.9
Undetermined	16.5	30.7	21.5	14.0	9.8	4.5	7.0	17.0	8.4	20.5	17.6
Number of facilities	146	280	65	1,508	122	134	200	141	740	904	5,263

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

Darkroom procedures. Under the item "light-tightness of darkroom" (table 2), the offices of pediatricians and internists show the highest percent of facilities having no darkroom. This may be due to the high percentage possessing fluoroscopes that are not part of a combination unit having both radiographic and fluoroscopic capabilities. The data indicate that automatic film processing units are most likely to be found in facilities with the largest workloads (radiologists' offices and hospitals).

Equipment type and operating characteristics. Table 3 shows the variations in maximum kilovoltage and maximum milliamperage. The category "unknown" under maximum kilovoltage peak shows several results between 10 and 18 percent. These, and probably most of the unknowns, may conceivably be attributed to older equipment. There are fewer "unknowns" for the maximum milliamperage category. This is not unreasonable since milliamperage is more likely to be known on the same equipment for which kilovoltage is not known.

Filtration. As can be seen in table 4, there was an increase in the percentage of units having 2.5 mm or more aluminum equivalent filtration from the "before survey" to the "after survey" findings. This probably reflects, at least in part, the effects of the Bureau of Radiological Health's program of supplying filters to the States. In reports to come, the data on filtration will be related to the kVp of the machine, to make the evaluation of filtration adequacy more meaningful.

Exposure switch, timer, and protective devices. Gonadal shields for patients do not appear to be in general use (table 5). They are often present in types of facilities and practices where the workload is greatest. These protective devices were present in 65 percent of radiologists' offices and in 33 percent of the offices of general practitioners. Other protective features were generally more widely used.

Procedures and related factors for the major part of the workload. As can be seen in table 6, a high percentage of the examinations for most specialties

Table 3. Equipment type and operation characteristics identification from medical x-ray protection surveys as of June 30, 1967, by type of facility or type of practice

Radiographic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Combination (radiographic-fluoroscopic capability):											
Yes	78.3	80.0	80.6	64.6	11.5	57.8	77.0	68.5	46.9	10.8	46.4
No	20.9	19.5	19.4	33.2	87.7	42.2	23.0	29.1	52.3	88.6	52.5
Unknown	.8	.6	.0	2.2	.8	.0	.0	2.4	.9	.6	1.1
Type of x-ray machine:											
Fixed radiographic	86.0	90.1	96.8	86.4	92.7	84.4	93.1	84.2	57.2	88.5	77.3
Photofluorographic	3.3	.6	.0	.1	.0	.0	1.0	4.2	3.2	.1	1.7
Mobile	4.5	.0	3.2	8.6	4.9	12.5	3.9	4.2	36.8	9.7	17.5
Other and unknown	6.1	9.4	.0	4.9	2.5	3.1	2.0	7.3	2.8	1.7	3.6
Maximum kilovolt peak:											
< 50	.0	.0	.0	.2	.0	.8	.0	.0	.25	.2	.4
50 – 74	.8	1.1	3.2	3.1	1.6	2.3	.0	1.2	2.3	3.5	4.4
75 – 99	4.9	20.6	19.4	17.6	13.1	27.3	10.8	6.7	16.8	33.6	18.9
100 –149	78.3	67.2	58.1	63.2	76.2	60.9	77.4	72.1	59.2	43.2	57.1
150 –249	11.9	.6	3.2	1.3	2.5	1.6	3.9	3.0	8.3	1.0	4.1
≥250	.8	.0	.0	.2	.8	.0	.5	.0	.7	.4	.4
Unknown	3.3	10.6	16.1	14.4	5.7	7.0	7.4	17.0	12.6	18.1	14.7
Maximum milliamperage:											
< 50	5.7	12.8	25.8	20.0	10.7	32.0	9.3	2.4	24.3	27.9	24.1
50 – 99	.0	6.7	9.7	9.3	1.6	9.4	3.4	3.0	3.2	20.2	8.7
100 –199	3.3	40.5	41.9	45.1	28.7	43.7	35.3	21.2	8.1	30.6	22.3
200 –299	31.1	26.1	12.9	13.8	42.6	10.2	28.9	38.2	23.5	4.6	18.4
300 –399	47.5	7.8	.0	4.2	11.5	2.3	17.2	17.6	25.4	.9	13.3
≥400	9.0	1.1	3.2	.4	1.6	.0	1.0	2.4	7.7	.4	3.1
Unknown	3.3	5.0	6.4	7.2	3.3	2.3	4.9	15.2	7.8	16.2	10.0
Number of x-ray machines	244	180	31	1,303	122	128	204	165	1,985	906	6,380

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

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Table 4. Filtration from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Radiographic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Total filtration before survey (mm. of Al. equivalent):											
<1.5	3.3	25.0	38.7	35.6	18.9	41.4	23.0	24.8	17.3	18.6	23.9
1.5 -2.4	14.8	27.2	29.0	27.7	25.4	26.0	26.5	21.2	16.1	23.1	22.2
≥2.5	76.1	37.8	25.8	32.8	54.1	29.0	45.6	47.2	58.5	54.7	47.8
Unknown[b]	5.7	10.0	6.4	3.8	1.6	3.1	4.9	6.7	8.2	3.5	6.2
Total filtration after survey (mm. of Al. equivalent):											
<1.5	2.4	13.3	16.1	14.6	11.5	14.8	9:3	7.9	9.8	4.4	10.4
1.5 -2.4	11.4	17.8	16.1	19.6	16.4	21.1	17.2	11.5	15.0	15.0	16.7
≥2.5	77.8	57.8	61.3	58.5	69.7	60.1	66.2	65.4	66.4	75.8	64.7
Unknown[b]	7.4	11.1	6.4	7.2	2.5	3.9	7.4	15.2	8.8	4.7	8.0
Number of x-ray machines	244	180	31	1,393	122	128	204	165	1,985	906	6,380

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

[b] A large proportion of "unknowns" in this group represents entries not checked off because the filtration was not changed. Please note that "total filtration" after survey showed improving trend.

Table 5. Exposure switch, timer, and protection devices from medical x-ray protection surveys as of June 30, 1967, by type of facility or type of practice

Radiographic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Exposure switch location—adequate	77.9	82.2	96.8	86.1	91.0	85.9	92.2	85.4	83.9	89.3	85.5
Timer—adequate	98.0	96.7	93.6	97.1	95.8	96.8	98.5	97.6	94.4	94.5	95.5
Gonadal shields for patients present	65.2	36.7	32.3	33.4	54.1	22.6	40.7	59.4	48.0	26.9	38.2
Operator protection—adequate	95.9	83.3	83.9	94.6	93.5	77.3	91.7	93.3	90.8	87.5	87.7
Primary and secondary barriers—adequate	92.6	79.4	80.6	84.1	90.2	82.0	89.7	85.4	77.3	89.5	83.4
Diagnostic type tube housing	84.0	81.1	80.6	83.5	90.2	92.9	87.2	80.6	85.2	93.0	86.7
Number of x-ray machines	244	180	31	1,393	122	128	204	165	1,985	906	6,380

The difference between the percentages presented and 100 percent is accounted for by negative or unknown categories.

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

were chest examinations. Orthopedists reported about as many extremity procedures as chest examinations. Two-thirds of the chiropractors reported procedures on the spine as their major part of the workload.

Proper beam size is determined on the spot by the surveyors. In the case of rectangular collimation, the surveyor has been instructed to allow no more than 1 inch on each side over and above the film dimensions. Hence, beam size for a 14- by 17-inch film should not exceed 16- by 19-inches. In the case of circular collimation, no more than 1 inch is allowed on each end of a diagonal through the film. This permits a beam diameter of 24 inches when a 14- by 17-inch film is required.

It appears that in a majority of the examinations reported, a circular x-ray beam was used with a 14- by 17-inch film. The beam size associated with 32 percent of such examinations is equal to or greater than 25 inches. Inasmuch as the long diagonal of the 14- by 17-inch film is only 22 inches, none of the facility categories is free of some problem in proper collimation according to film size. For hospitals and for radiologists' offices excessive beam size occurs in 21 and 25 percent of the facilities, respectively. This indicates that in a number of facilities the reduction of improper beam size remains as an area of needed emphasis. There appears also to exist a relationship between proper collimation and the use of a variable collimator. In most instances where the percentage of the machines having variable collimation is low, the percentage showing improper collimation is high (chiropractors are an exception).

Table 6. Procedures and related factors for major part of workload from medical x-ray protection surveys as of June 30, 1967, by type of facility or type of practice

Radiographic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities^a
Usual type of examination:											
Chest	70.6	94.4	83.9	82.7	21.3	80.1	91.2	87.3	82.7	8.9	80.0
Extremities	2.4	.0	6.4	8.0	50.3	6.2	3.9	2.4	5.7	2.4	3.5
Spine	2.4	1.1	3.3	.4	17.3	9.4	.5	.0	.9	83.1	10.8
Usual kilovolt peak:											
50–74	49.2	86.1	58.1	67.6	60.7	59.4	69.6	61.8	48.1	50.8	55.3
75–99	36.5	10.4	29.0	14.3	23.0	14.1	19.6	34.2	31.3	31.0	34.1
Usual milliampere-seconds:											
< 6	11.9	11.1	26.8	10.7	12.3	6.2	12.8	6.1	17.4	3.3	11.4
6–25	61.5	70.1	61.3	72.2	60.8	64.1	78.4	77.6	61.9	17.8	53.6
26–75	10.7	4.4	3.3	5.3	12.3	3.9	2.5	5.4	11.6	37.5	11.8
Usual film size (inches):											
14 by 17	81.2	94.4	64.5	80.7	47.5	69.5	92.6	88.5	70.8	49.5	67.0
10 by 12	6.2	1.7	19.4	5.1	16.4	3.3	3.4	2.4	10.0	4.6	7.8
8 by 10	.4	.6	6.4	6.7	25.4	9.4	1.5	1.2	4.0	31.4	10.7
Usual film distance (inches):											
30–39	6.2	1.7	12.9	11.4	35.2	21.9	4.9	6.7	17.4	47.2	19.8
40–49	9.8	5.0	6.4	3.6	27.0	5.5	1.5	4.2	16.6	39.2	11.1
70–79	73.4	87.2	67.7	75.2	30.3	34.7	88.3	83.6	47.1	7.7	50.1
Usual beam type:											
Circular	50.0	67.2	87.1	74.2	61.5	66.4	58.8	64.2	47.6	66.6	59.7
Rectangular	32.8	22.8	6.4	10.3	22.1	12.5	25.5	21.2	29.9	14.6	20.0
Square	3.7	3.3	.0	3.4	4.1	2.3	2.4	1.8	6.7	3.1	4.2
Usual beam size (inches):											
<20	34.4	10.6	16.1	13.7	46.7	17.2	22.6	17.0	37.1	30.4	37.5
20–24	23.0	12.8	12.9	14.9	19.7	17.9	12.7	17.0	21.1	19.3	17.7
≥25	36.4	66.1	61.3	58.9	14.0	30.8	48.0	53.3	30.8	30.3	32.0
Collimation:											
Proper	30.7	17.8	19.4	22.6	36.9	33.1	23.0	18.8	27.7	48.1	30.2
Improper	17.6	66.7	64.5	53.1	22.9	44.6	45.1	46.1	20.7	22.5	32.8
Variable	43.0	8.3	6.4	7.8	28.7	7.8	17.6	19.4	34.7	8.0	18.8
Permanent	.0	.0	.0	.7	.0	.0	.0	.0	.2	2.9	1.1
Number of x-ray machines	244	180	31	1,288	122	128	204	165	1,985	906	6,280

The difference between the percentages presented and 100 percent is accounted for by infrequently reported items of information and negative or unknown categories.

[a] All facilities includes information from 1,022 facilities that cannot be classified specifically in any of the above categories.

Fluoroscopic equipment characteristics (table 7). Over 50 percent of the x-ray machines in the possession of internists have fluoroscopic capability only, and more than 60 percent of the x-ray machines with fluoroscopic capability are of the vertical type. It may be noted that nearly one-half of all x-ray machines with fluoroscopic capability are in hospitals or in radiologists' offices. Only 15 percent of these facilities possess image intensifying devices, the other facilities fare more poorly in this capability for reducing patient exposure.

Fluoroscopic screens. As shown in table 8, fluoroscopic screens are not interlocked with x-ray tube in approximately 15 to 25 percent of the facilities of pediatricians, osteopaths, and chiropractors; in such situations the operator may be subjected to excessive exposure. There is no immediate explanation for the high percentage in the "undetermined" category for leaded screens among general practitioners in private offices and clinics.

The findings of a fairly high percentage of cases (40 percent) in which the useful beam is not limited to the fluoroscopic screen, as compared to the low percentage of cases (8 percent) of improperly functioning shutters, may be explained in part by the failure of the surveyor to evaluate shutter function and beam limitation at the maximum screen-to-target distance.

Target-to-panel distance, roentgen output at the panel surface, lighttightness of fluoroscopic room (table 9). In most instances, target-to-panel distances comply with the recommendations in NBS Handbook 76 (*8*) and NCRP Report No. 33 (*9*).

Table 7. Equipment identification from medical x-ray protection surveys as of June 30, 1967, by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Combination (radiographic-fluoroscopic capability):											
Yes	98.3	42.5	19.5	69.8	--------	85.3	92.1	92.2	95.4	85.0	79.4
No	1.1	56.5	80.5	27.4	--------	11.8	5.9	6.5	4.1	10.0	19.3
Unknown	.6	.9	.0	2.8	--------	2.9	2.0	1.3	.5	5.0	1.2
Type:											
Vertical	.0	64.0	9.8	31.5	--------	23.5	6.9	7.8	2.5	25.0	19.3
Horizontal	3.9	3.3	70.7	7.2	--------	20.6	5.9	2.6	3.7	20.0	6.7
Tilting table	96.1	30.8	19.5	55.3	--------	50.0	83.2	80.5	91.9	50.0	70.9
Unknown	.0	1.9	.0	6.0	--------	5.9	4.0	9.1	1.9	5.0	3.1
Image intensifying device used:											
Yes	16.0	1.9	.0	1.3	--------	5.9	4.0	5.2	14.1	.0	7.9
No	81.2	95.8	97.6	91.3	--------	82.3	90.1	83.1	82.6	95.0	87.0
Unknown	2.8	2.3	2.4	7.4	--------	11.8	5.9	11.7	3.3	5.0	5.1
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Table 8. Fluoroscopic screens from medical x-ray protection surveys from 25 States and 2 territories as of June 30, 1967, by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Fluoroscopic screen ganged to x-ray tube:											
Yes	98.3	93.5	73.2	86.2	--------	76.5	87.1	93.5	96.9	75.0	91.8
No	.0	3.3	14.6	3.8	--------	14.7	.0	2.6	.7	15.0	3.0
Unknown	1.7	3.3	12.2	10.0	--------	8.8	12.9	3.9	2.4	10.0	5.1
Shutter functioning:											
Properly	94.5	86.0	78.0	76.8	--------	61.8	77.2	87.0	91.1	75.0	85.6
Improperly	3.9	9.8	12.2	11.1	--------	17.6	6.9	9.1	5.0	5.0	7.5
Fixed	.0	.5	4.9	.4	--------	5.9	.0	.0	.6	10.0	.8
Undetermined	1.7	3.7	4.9	11.7	--------	14.7	15.8	3.9	3.3	10.0	6.1
Useful beam limited to screen:											
Yes	68.5	38.3	46.3	32.1	--------	35.3	52.5	59.7	69.8	40.0	52.3
No	28.2	55.6	46.3	53.8	--------	41.2	30.7	35.1	26.1	50.0	40.2
Unknown	3.3	6.1	7.3	14.0	--------	23.5	16.8	5.2	4.0	10.0	7.5
Leaded screen (from revised form only):											
Satisfactory	87.9	91.0	--------	73.5	--------	--------	46.2	--------	90.1	--------	81.8
Not satisfactory	3.0	4.4	--------	.8	--------	--------	.0	--------	2.5	--------	2.0
Not applicable	1.5	.0	--------	2.5	--------	--------	3.8	--------	2.9	--------	2.6
Undetermined	7.6	4.4	--------	23.1	--------	--------	50.0	--------	4.4	--------	13.6
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266
Number of fluoroscopic cards (revised form)	66	45	[b] 1	121	[b] 2	[b] 3	26	[b] 5	238	[b] 2	544

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

In at least 86 percent of the cases the target-to-panel distance was at least 12 inches. Operation at a distance of less than 12-inches distance was observed in about 8 to 9 percent of pediatrician, private offices of general practitioners, and osteopath facilities. This may account in part for the relatively high percentage of outputs in excess of 10 roentgens per minute at the panel surface for these specialties. The high percentage of facilities reporting less than 10 roentgens per minute is note-

Table 9. Distance, roentgen output and fluoroscopic room from medical x-ray protection surveys of June 30, 1967, by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Target-to-panel distance (inches):											
<12	.0	7.5	2.4	8.5	....	8.8	2.0	.0	0.6	.0	3.8
12–14	5.5	46.3	48.8	28.3	....	17.6	8.9	14.3	5.7	20.0	19.4
15–17	22.1	19.6	24.4	27.9	....	23.5	22.8	24.7	15.4	25.0	20.5
18–20	63.0	17.8	12.2	17.9	....	32.4	41.6	46.8	69.1	10.0	39.3
≥21	2.8	.9	2.4	2.6	....	.0	3.0	1.3	3.4	15.0	2.7
Unknown	6.6	7.9	9.8	14.9	....	17.6	21.8	13.0	5.8	30.0	9.9
Percent in compliance with Handbook 76 (*2*)	93.4	84.6	87.8	76.6	....	73.6	76.2	87.0	93.6	70.0	86.3
Roentgen output at panel surface (R/min):											
< 1.0	1.1	.9	.0	1.3	....	.0	.0	1.3	2.2	.0	1.5
1.0– 9.9	89.5	59.4	58.5	60.0	....	32.4	72.3	79.2	84.1	45.0	71.8
10.0–14.9	5.5	15.4	17.1	7.7	....	14.7	4.0	10.4	4.1	5.0	7.4
15.0–19.9	.0	6.5	7.3	4.5	....	5.9	.0	2.6	1.4	10.0	3.2
≥20.0	1.2	10.3	14.7	8.2	....	8.8	3.0	1.3	1.2	5.0	4.8
Unknown	2.8	7.5	2.4	18.3	....	38.2	20.8	5.2	6.9	35.0	11.4
Percent in compliance with Handbook 76 (*2*)	90.6	60.3	58.5	61.3	....	32.4	72.3	80.5	86.3	45.0	73.3
Lighttightness of fluoroscopic room:											
Lighttight	75.1	65.9	53.7	55.7	....	52.9	64.4	70.1	69.6	30.0	64.5
Not lighttight	12.7	23.8	26.8	23.4	....	29.4	12.9	15.6	19.0	55.0	20.1
Not applicable	2.2	.5	.0	.2	....	.0	.0	.0	2.6	.0	1.3
Unknown	9.9	9.8	19.5	20.6	....	17.6	22.8	14.3	8.8	15.0	14.1
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

worthy, and suggests that the 10 roentgens per minute limit specified in NBS Handbook 76 can be reduced.[3] It is of interest that the types of facility that reported less than 1 roentgen per minute are the same types that reported using image intensifying devices. NCRP Report No. 33 (*3*) prescribes the expression of output at the panel surface in terms of roentgens per milliampere-minute; future reports on surveys will attempt to comply with this recommendation.

With regard to lighttightness of the fluoroscopic room, the types of facilities that reported the item as "not applicable" were the same as those reporting the use of image intensifying devices.

Fluoroscopic filtration. This parameter is difficult to measure in the type of survey conducted, since it would in most instances, necessitate the partial dismantling of the fluoroscopic table. This accounts for the high percentage of "unknown" shown in table 10, and suggests a need for the training of survey personnel in methods of determining filtration of fluoroscopes by indirect means such as half-value-layer determinations.

Time information. The percentage of facilities reporting fluoroscopes that are not equipped with manually reset cumulative timers is of particular interest. As indicated in table 11, this percentage is high where one might expect to find older equipment; this might even serve to indicate the general age of equipment. A timer can be an expensive addition to old equipment, and many owners might be reluctant to add this feature voluntarily without a vigorous program in the State.

Dark adaptation. The data in table 12 show that pediatricians and osteopaths, in particular, are likely to dark adapt for a shorter time period than the average for the sample. One might speculate that this could be associated with increased patient exposure, if dark adaptation is insufficient and the milliamperage is set higher than would be necessary with proper dark adaptation practices.

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[3] The State of New Jersey Radiation Protection Code, Chapter 2, Section 18.2.11 (January 1965) restricts the output at the panel surface to 5 roentgens per minute or less and has had no difficulty in obtaining compliance.

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Table 10. Filtration from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
	Type of facility or type of practice (percent)										
Total filtration before survey (mm. of Al. equivalent):											
<1.5	2.3	16.4	29.2	24.7	--------	23.5	7.0	13.0	4.4	15.0	12.4
1.5 -2.4	2.8	14.5	24.4	14.4	--------	23.5	10.9	5.2	3.3	20.0	9.4
≥2.5	52.5	36.4	19.5	33.2	--------	38.3	43.6	46.8	49.9	40.0	42.7
Unknown[b]	42.5	32.7	26.8	27.7	--------	14.7	38.6	35.1	42.4	25.0	35.5
Percent in compliance with Handbook 76 (*2*)	52.5	36.4	19.5	33.2	--------	38.3	43.6	46.8	49.9	40.0	42.7
Total filtration after survey (mm. of Al. equivalent):											
<1.5	.6	12.2	12.2	13.9	--------	14.7	3.0	7.8	2.7	5.0	7.3
1.5 -2.4	2.8	12.2	17.1	10.7	--------	23.5	11.8	.0	2.8	20.0	7.6
≥2.5	51.9	41.1	41.5	45.5	--------	41.2	45.6	49.4	51.1	45.0	47.8
Unknown[b]	44.8	34.6	29.3	30.0	--------	20.6	39.6	42.9	43.3	30.0	37.6
Percent in compliance with Handbook 76 (*2*)	51.9	41.1	41.5	45.5	--------	41.2	45.6	49.4	51.1	45.0	47.8
Number of x-ray machines	181	214	41	470	[c] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] A large proportion of "unknowns" in the group represents entries not checked off because the filtration was not changed from the previous conditions. Please note that "total filtration" after survey showed improving trend.
[c] Sample size too small to provide meaningful data.

Table 11. Timer information from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
	Type of facility or type of practice (percent)										
Deadman type of exposure switch:											
Yes	97.8	94.4	95.1	88.3	--------	85.3	86.1	96.1	97.2	90.0	93.8
No	.6	2.3	.0	1.5	--------	2.9	1.0	.0	.6	.0	1.2
Unknown	1.7	3.3	4.9	10.2	--------	11.8	12.9	3.9	2.1	10.0	5.0
Manually reset cumulative timer:											
Yes	58.0	21.0	12.2	18.1	--------	17.6	25.7	40.3	56.4	5.0	38.0
No	39.8	77.6	85.4	73.6	--------	73.5	57.4	55.8	41.4	85.0	57.5
Unknown	2.2	1.4	2.4	8.3	--------	8.8	16.8	3.9	2.1	10.0	4.5
Cumulative timer terminates exposure:											
Yes	56.9	20.1	12.2	16.4	--------	20.6	22.8	40.3	56.1	5.0	37.2
No	40.3	77.1	82.9	74.5	--------	70.6	58.4	55.8	41.6	85.0	57.7
Unknown	2.8	2.8	4.9	9.2	--------	8.8	18.8	3.9	2.2	10.0	5.0
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Accessory shielding. The absence of Bucky-slot covers and leaded drapes around the screen seems to correlate with types of facility having older equipment. The data in table 13 tend to support the premise that in facilities where the equipment is likely to be new or of recent vintage, these accessories are more likely to be present than in facilities with older equipment.

Upper gastrointestinal examinations. It is evident from the data in table 14 that the heaviest load of upper gastrointestinal examinations occurs in radiologists' offices and in hospitals. The high percentage in the "unknown" category reported for internist and general practitioners may well be due to the infrequency of the procedure in these specialties, and that the coding for "un-

Table 12. Dark adaptation from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Number of minutes of dark adaptation:											
< 5	7.7	7.5	14.6	16.6	....	20.6	8.9	1.3	8.3	25.0	10.3
5 – 9	3.3	16.4	43.9	10.4	....	11.8	3.0	10.4	3.6	20.0	8.1
10 –14	13.8	22.0	14.6	17.2	....	20.6	12.9	13.0	12.4	5.0	15.6
15 –19	32.0	19.6	2.4	13.6	....	8.8	13.9	32.5	25.3	5.0	20.8
≥20	32.6	15.0	.0	16.2	....	11.8	34.6	22.1	40.2	15.0	27.2
Unknown	10.5	19.6	24.4	26.0	....	26.5	26.7	20.8	10.2	30.0	18.0
Average minutes per user	17.5	13.7	7.3	12.8	....	11.1	17.7	16.8	18.1	10.1	15.8
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

[b] Sample size too small to provide meaningful data.

known" rather than "not performed" was used. The duration of tube activation per examination does not vary too greatly from the average of 3.1 minutes.

Lower gastrointestinal examination. The data in table 15 indicate that lower gastrointestinal examinations are also performed chiefly in radiologists' offices and in hospitals. Also, the coding for "unknown" is considered to be subject to the same error as for the upper tract examinations. The duration of tube activation per examination averaged 2.9 minutes.

Spot films and fluoroscopic examinations other than gastrointestinal. As can be seen (table 16), all other fluoroscopic examinations combined do not equal the number involving the gastrointestinal region. The distribution by number of spot films which may be a part of any fluoroscopic examination is roughly consistent with the fluoroscopic patient workload. This is particularly evident in the rate of spot films taken in radiologists' offices, hospitals, and multiple specialty clinics.

Table 13. Accessory shielding from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Leaded gloves:											
Yes	97.8	90.2	95.1	83.4	....	70.6	85.2	94.8	98.4	70.0	92.2
No	1.7	7.9	4.9	11.3	....	20.6	3.0	2.6	1.0	20.0	5.2
Unknown	.6	1.9	.0	5.3	....	8.8	11.9	2.6	.6	10.0	2.6
Leaded apron:											
Yes	98.3	91.6	82.9	83.8	....	76.5	85.2	92.2	98.3	70.0	91.9
No	1.1	7.0	17.1	12.1	....	14.7	3.0	6.5	1.1	20.0	5.8
Unknown	.0	1.4	.0	4.0	....	8.8	11.9	1.3	.6	10.0	2.2
Bucky slot cover:											
Yes	52.5	12.1	2.4	9.8	....	8.8	29.7	18.2	58.4	10.0	34.0
No	45.9	40.2	48.8	62.8	....	73.5	52.5	74.0	37.9	65.0	48.6
Not applicable	.0	45.3	48.8	22.3	....	11.8	5.0	5.2	2.5	15.0	14.4
Unknown	1.7	2.3	.0	5.1	....	5.9	12.9	2.6	1.2	10.0	3.0
Leaded drapes around screen:											
Yes	39.2	6.1	2.4	6.4	....	8.8	16.8	15.6	35.1	10.0	21.3
No	60.2	63.1	56.1	78.1	....	79.4	71.3	79.2	60.3	80.0	67.1
Not applicable	.0	28.5	41.5	11.3	....	5.9	.0	2.6	2.4	.0	7.9
Unknown	.6	2.3	.0	4.3	....	5.9	11.9	2.6	2.1	10.0	3.6
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

[b] Sample size too small to provide meaningful data.

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Table 14. Upper gastrointestinal examination from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information (revised form)	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Kilovolt peak:											
Not performed	.0	26.6	....	26.4	....	....	3.8	....	2.5	....	12.3
< 50	.0	.0	....	.8	....	....	.0	....	.0	....	.2
50– 74	10.6	11.1	....	14.9	....	....	7.7	....	6.7	....	9.4
75– 99	66.7	22.2	....	15.7	....	....	23.1	....	57.5	....	42.6
100–149	6.1	.0	....	.8	....	....	.0	....	8.8	....	4.8
≥150	.0	2.2	....	.0	....	....	.0	....	.8	....	.6
Unknown	16.7	37.7	....	41.3	....	....	65.4	....	23.5	....	30.1
Minutes tube activated per exam:											
Not performed	.0	26.6	....	26.4	....	....	3.8	....	2.5	....	12.3
1	6.1	11.1	....	12.4	....	....	.0	....	2.1	....	6.1
2	22.7	17.8	....	4.1	....	....	11.5	....	19.7	....	15.1
3	18.2	4.4	....	8.3	....	....	19.2	....	26.0	....	17.1
4	12.1	2.2	....	3.3	....	....	.0	....	10.1	....	7.7
5	22.7	2.2	....	3.3	....	....	3.8	....	11.8	....	9.4
≥ 6	1.5	.0	....	.0	....	....	.0	....	1.7	....	1.1
Unknown	16.7	35.5	....	42.1	....	....	61.5	....	26.0	....	31.2
Average number of minutes	3.3	2.1	....	2.4	....	....	2.9	....	3.2	....	3.1
Number of examinations per week:											
Not performed	....	26.6	....	29.8	....	....	7.7	....	3.4	....	12.3
< 5	12.1	28.9	....	24.8	....	....	34.6	....	26.0	....	23.5
5– 9	24.2	6.7	....	1.6	....	....	.0	....	13.0	....	10.3
10–14	22.7	.0	....	1.6	....	....	.0	....	10.9	....	8.4
15–19	9.1	.0	....	.0	....	....	.0	....	6.7	....	4.4
20–29	10.6	.0	....	.8	....	....	.0	....	8.4	....	5.3
≥30	4.5	2.2	....	.8	....	....	.0	....	6.7	....	4.3
Unknown	16.7	35.5	....	40.5	....	....	57.7	....	24.8	....	31.4
Average number of exams	12.5	5.2	....	5.1	....	....	2.0	....	13.0	....	11.5
Number of x-ray machines	66	45	[b] 1	121	[b] 2	[b] 3	26	[b] 5	238	[b] 2	544

[a] All facilities includes information from 35 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Table 15. Lower gastrointestinal examination from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information (revised form)	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Kilovolt peak:											
Not performed	1.5	31.1	....	32.2	....	....	3.8	....	3.8	....	15.3
< 50	.0	.0	....	.0	....	....	.0	....	.0	....	.0
50– 74	12.1	6.7	....	10.7	....	....	7.7	....	7.1	....	8.3
75– 99	65.2	13.3	....	8.3	....	....	23.1	....	56.3	....	38.6
100–149	3.0	.0	....	.0	....	....	.0	....	8.4	....	4.0
≥150	.0	.0	....	.0	....	....	.0	....	.0	....	.0
Unknown	18.2	48.8	....	48.8	....	....	65.4	....	24.4	....	33.8
Minutes tube activated per examination:											
Not performed	1.5	31.1	....	32.2	....	....	3.8	....	3.8	....	15.3
1	9.1	4.4	....	4.1	....	....	.0	....	5.5	....	5.2
2	31.8	11.1	....	3.3	....	....	11.5	....	21.4	....	16.2
3	21.2	2.2	....	5.8	....	....	19.2	....	25.2	....	16.4
4	6.1	2.2	....	3.3	....	....	.0	....	8.8	....	6.4
5	12.1	.0	....	2.5	....	....	3.8	....	8.0	....	5.7
≥6	.0	.0	....	.0	....	....	.0	....	1.2	....	.6
Unknown	18.2	48.8	....	48.8	....	....	61.5	....	26.0	....	34.4
Average number of minutes	2.8	2.1	....	2.8	....	....	2.9	....	3.0	....	2.9
Number of examinations per week:											
Not performed	1.5	31.1	....	33.9	....	....	7.7	....	4.2	....	15.3
< 5	28.8	13.3	....	14.9	....	....	34.6	....	31.5	....	24.3
5– 9	30.3	2.2	....	1.6	....	....	.0	....	12.2	....	9.9
10–14	7.6	4.4	....	.8	....	....	.0	....	11.3	....	7.0
15–19	12.1	.0	....	.0	....	....	.0	....	5.9	....	4.2
20–29	3.0	.0	....	.8	....	....	.0	....	6.7	....	3.7
≥30	.0	.0	....	.0	....	....	.0	....	2.9	....	1.5
Unknown	16.7	48.8	....	47.9	....	....	57.7	....	25.2	....	34.2
Average number of examinations	7.8	4.8	....	4.3	....	....	2.0	....	9.5	....	8.4
Number of x-ray machines	66	45	[b] 1	121	[b] 2	[b] 3	26	[b] 5	238	[b] 2	544

[a] All facilities includes information from 35 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

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Table 16. Other examinations and spot films from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information (revised form)	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Number of other examinations per week:											
None	20.4	14.0	7.3	15.1	....	8.8	10.9	6.5	23.0	10.0	16.5
<10	16.6	21.9	.0	27.2	....	11.8	16.9	10.5	19.7	25.0	21.5
10-19	5.0	6.0	.0	2.3	....	.0	1.0	1.3	6.5	.0	4.7
20-39	4.4	4.6	.0	1.0	....	.0	.0	6.5	3.4	.0	3.0
≥40	.6	.0	.0	.8	....	.0	.0	1.3	1.2	.0	.9
Unknown	53.0	53.0	92.7	53.4	....	79.4	71.3	64.9	46.1	65.0	53.4
Average number per week	11.0	9.0	2.0	6.1	....	2.5	3.9	11.8	10.8	2.0	9.0
Number of spot films per week:											
None	6.6	69.2	63.4	57.0	....	50.0	24.8	26.0	17.7	75.0	37.4
< 10	5.5	6.1	4.9	9.6	....	.0	17.8	5.2	11.0	5.0	8.7
10- 24	9.9	4.6	.0	3.6	....	5.9	9.9	13.0	11.6	.0	7.9
25- 49	14.9	.9	.0	.4	....	2.9	9.9	18.2	12.5	.0	7.6
50- 99	18.3	.4	.0	1.9	....	.0	4.0	11.7	15.0	.0	8.5
100-199	22.1	.9	.0	.6	....	.0	3.0	5.2	11.6	.0	6.7
≥200	10.0	.0	.0	.0	....	.0	1.0	2.6	5.6	.0	3.2
Unknown	12.7	17.8	31.7	26.8	....	41.2	29.7	18.2	14.9	20.0	20.0
Average number per week	111.2	22.5	5.0	21.9	....	20.3	36.1	63.9	81.1	5.0	75.7
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Table 17. Total milliampere-minute workload from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information (revised form)	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Total mA-min/week:											
Not performed	1.5	8.9	....	18.2	....	....	7.7	....	6.7	....	8.8
< 50	21.2	55.5	....	44.6	....	....	26.9	....	26.5	....	33.3
50- 99	13.6	4.4	....	5.0	....	....	7.7	....	12.6	....	9.6
100-149	6.1	8.9	....	.0	....	....	.0	....	10.5	....	6.8
150-249	18.2	.0	....	.8	....	....	.0	....	12.2	....	8.6
250-499	18.2	.0	....	.0	....	....	.0	....	12.6	....	8.1
≥500	1.5	.0	....	.0	....	....	.0	....	8.0	....	3.9
Unknown	19.7	22.2	....	31.4	....	....	57.7	....	10.9	....	21.0
Average mA-min/week	174.0	41.1	....	32.7	....	....	36.1	....	197.1	....	144.4
Number of x-ray machines	66	45	[b] 1	121	[b] 2	[b] 3	26	[b] 5	238	[b] 2	544

[a] All facilities includes information from 35 facilities that cannot be classified in any of the above categories.
[b] Sample size too small to provide meaningful data.

Total milliampere-minutes workload. As would be expected, the greatest part of the fluoroscopic workload is handled in radiologists' offices and in hospitals (table 17).

It should be noted that in tables 14, 15, and 17, there are fewer machines reported than in the other fluoroscopic tables. This change in total numbers is also indicated within table 8. This should be taken into account in relating absolute numbers recorded for the specialties according to procedure and equipment.

Conclusions and recommendations.

The following areas in which major efforts should be made are suggested:

Equipment. The high percentage of facilities having improper collimation, inadequate filtration, lack of accessory shielding, and absence of manually reset cumulative timers on fluoroscopes, indicate that a major effort in the correction of equipment is still needed. This effort, if applied, would help in the reduction of unnecessary population and occupational exposure.

Standardization of survey techniques and data collection. The high percentage of "unknowns" in the data reported emphasize the need for the standardization of surveying techniques and for uniformity and comparability of data collected in State radiological health programs. Survey forms should also be revised using NCRP Report No. 33 as a guide, and all data inquiries should be eliminated that are of doubtful value in defining or assessing radiological health problems and progress.

Technique and judgment. A continuing effort aimed at improving the technique of the operator of the machine and the professional judgment of the physician requesting the examination is essential if the efforts toward dose reduction are to be successful. The use of fluoroscopy in cases where a radiograph would serve a more useful purpose, and inadequate beam collimation in facilities where adequate collimating devices are available, reinforce this conclusion.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, February 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostron-

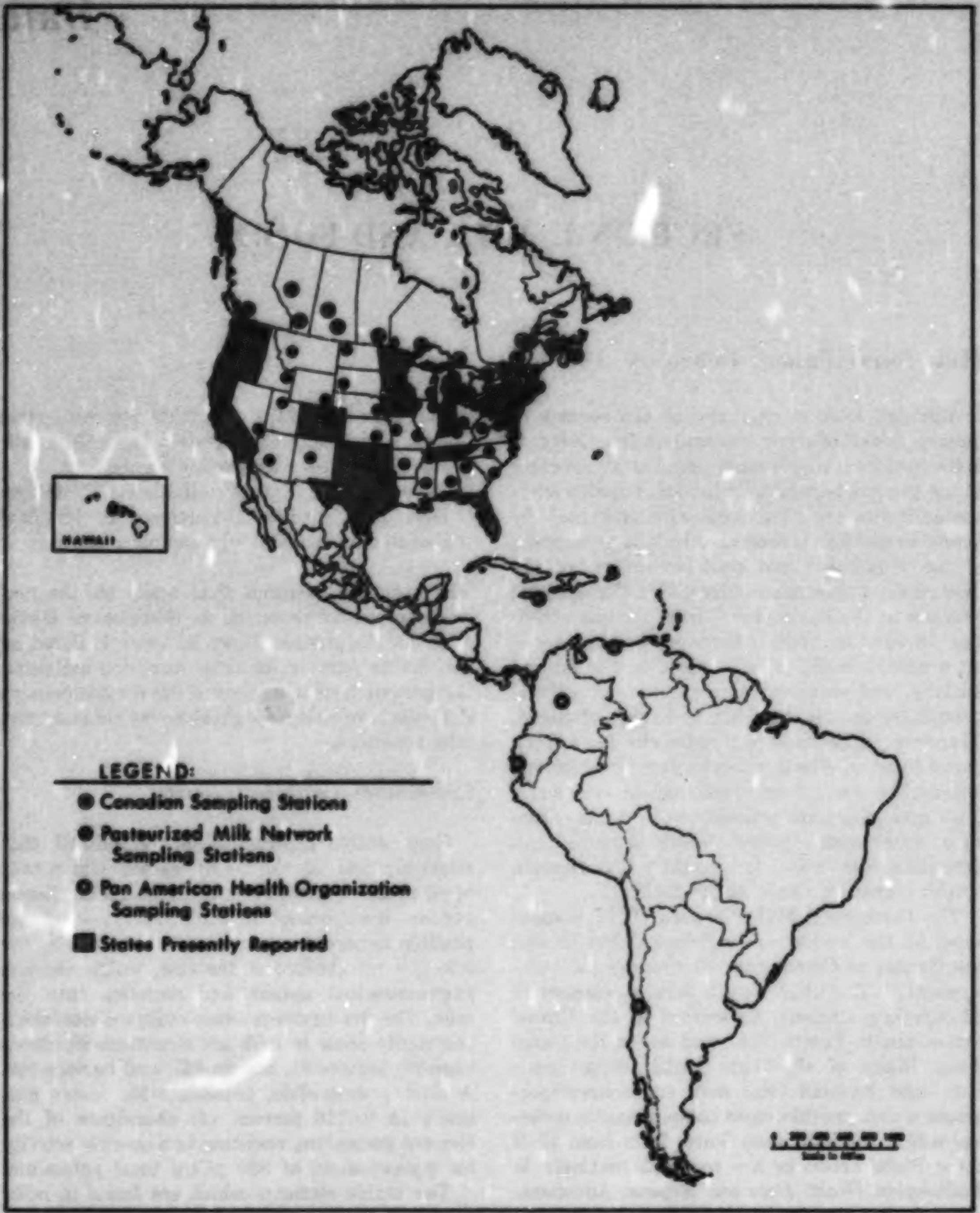
HAWAII
LEGEND:
● Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Health Organization Sampling Stations
▨ States Presently Reported
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

tium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3- standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium–137 are relatively constant over short time periods and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation will also reflect whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviations
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/yr)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c].5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c].5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1- or 2- year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentra-

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89 Strontium-90 Cesium-137	Bone marrow Bone marrow Whole body	10 in first year total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000 [c]51,000 [c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

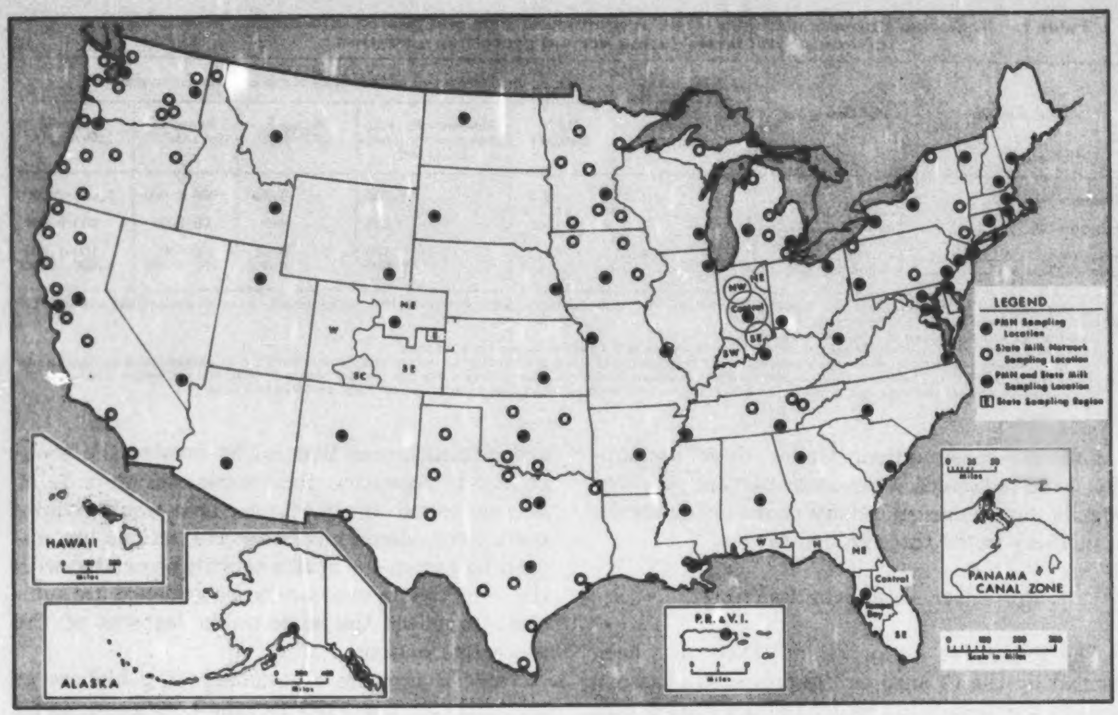

Figure 2. State and PMN milk sampling locations in the United States

tion from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-month average, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137, for February 1969 and the 12-month period, March 1968 to February 1969. Except where noted

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Table 3. Concentration of radionuclides in milk for February 1969 and 12-month period, March 1968 through February 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	10	8	0(4)	0	8(4)	14
Alaska:	Palmer[c]	P	7	6	0(3)	0	10(3)	13
Ariz:	Phoenix[c]	P	3	1	0(4)	0	0(4)	2
Ark:	Little Rock[c]	P	18	20	0(4)	0	31(4)	19
Calif:	Sacramento[c]	P	0	2	0(7)	0	0(3)	4
	San Francisco[c]	P	4	2	0(4)	0	0(4)	3
	Del Norte	P	10	19	0	0	20	21
	Fresno	P	0	1	0	0	0	3
	Humboldt	P	0	4	0	0	13	12
	Los Angeles	P	0	1	0	0	0	5
	Mendocino	P	0	2	0	0	0	4
	Sacramento	P	0	2	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	6
	Shasta	P	0	3	0	0	11	4
	Sonoma	P	0	1	0	0	0	4
Colo:	Denver[c]	P	5	5	0(4)	0	0(4)	5
	West	R	(d)		(e)	(e)	(e)	(e)
	Northeast	R	(d)		(e) (3)	1	(e)	(e)
	East	R	(d)		NS	(e)	NS	
	Southeast	R	(d)		NS		NS	
	South Central	R	(d)		NS		NS	
Conn:	Hartford[c]	P	7	9	0(4)	0	13(4)	12
	Central	P	7	8	0(4)	0	4(4)	9
Del:	Wilmington[c]	P	10	10	0(4)	0	15(4)	9
D.C:	Washington[c]	P	9	9	0(3)	0	4(3)	6
Fla:	Tampa[c]	P	8	8	0(4)	0	49(4)	65
	West	R	16	12	0	3	27	23
	North	R	10	14	0	0	31	30
	Northeast	R	11	9	0	2	34	80
	Central	R	10	9	0	2	108	83
	Tampa Bay area	R	8	8	0	0	55	72
	Southeast	R	9	9	0	0	84	114
Ga:	Atlanta[c]	P	11	14	0(4)	0	22(4)	20
Hawaii:	Honolulu[c]	P	5	4	0(4)	0	0(4)	2
Idaho:	Idaho Falls[c]	P	6	6	0(4)	0	10(4)	9
Ill:	Chicago[c]	P	7	9	0(4)	0	9(4)	10
Ind:	Indianapolis[c]	P	8	8	0(4)	0	10(4)	6
	Northeast	P	6	12	0	0	10	12
	Southeast	P	6	10	0	0	20	13
	Central	P	5	9	0	0	10	10
	Southwest	P	4	9	0	0	10	12
	Northwest	P	6	9	0	0	10	12
Iowa:	Des Moines[c]	P	4	6	0(4)	0	10	5
	Iowa City	P	5	7	0(2)	0	8(2)	6
	Des Moines	P	3	6	0(4)	0	8(4)	4
	Spencer	P	4	6	0	0	0	4
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	4	8	0(4)	0	NS	4
Ky:	Louisville[c]	P	10	12	0(4)	0	0(4)	7
La:	New Orleans[c]	P	16	20	0(4)	0	3(4)	23
Maine:	Portland[c]	P	11	12	0(4)	1	24(4)	28
Md:	Baltimore[c]	P	7	10	0(4)	0	21(4)	8
Mass:	Boston[c]	P	9	12	0(4)	0	6(4)	24
Mich:	Detroit[c]	P	9	9	0(4)	0	21(4)	11
	Grand Rapids[c]	P	10	10	0(4)	0	13(4)	15
	Bay City	P	NA	5	NA	0	NA	8
	Charlevoix	P	7	5	(e) (4)	(e)	16(4)	10
	Detroit	P	6	5	(e) (4)	(e)	7(4)	8
	Grand Rapids	P	7	4	(e) (4)	(e)	14(4)	8
	Lansing	P	NA	4	(e) (2)	(e)	0(2)	3
	Marquette	P	12	8	(e) (2)	(e)	25(2)	26
	Monroe	P	2	3	(e) (2)	(e)	7	1
	South Haven	P	7	4	(e) (3)	(e)	9(3)	5
Minn:	Minneapolis[c]	P	12	12	0(4)	0	18(4)	14
	Bemidji	P	12	16	0	0	21	25
	Mankato	P	4	6	0	0	10	0
	Rochester	P	8	9	0	0	0	0
	Duluth	P	18	20	0	0	26	31
	Worthington	P	6	6	0	0	14	0
	Minneapolis	P	10	12	0	0	16	15
	Fergus Falls	P	8	10	0	0	12	11
	Little Falls	P	10	10	0	0	17	17
Miss:	Jackson[c]	P	13	17	0(4)	0	15(4)	16
Mo.:	Kansas City[c]	P	5	7	0(4)	0	0(4)	4
	St. Louis[c]	P	8	9	0(4)	0	0(4)	5
Mont:	Helena[c]	P	3	4	0(4)	0	5(4)	8
Nebr:	Omaha[c]	P	5	7	0(4)	0	0(4)	5
Nev:	Las Vegas[c]	P	0	1	0(4)	0	0(4)	3
N.H:	Manchester[c]	P	8	13	0(4)	0	22(4)	34
N.J:	Trenton[c]	P	7	10	0(4)	0	7(4)	10
N. Mex:	Albuquerque[c]	P	0	3	0(4)	0	0(4)	2

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for February 1969 and 12-month period, March 1968 through February 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.Y:	Buffalo[c]	P	7	8	0(4)	0	15(4)	10
	New York City[c]	P	7	12	0(3)	0	11(3)	16
	Syracuse[c]	P	7	9	0(4)	0	7(4)	8
	Albany	P	12	9	0(4)	0	0(4)	0
	Buffalo	P	NA	7	NA	0	NA	0
	Massena	P	17	12	0	0	24	23
	Newburg	P	18	12	0(4)	0	0(4)	0
	New York City	P	18	12	0(3)	0	0(3)	0
	Syracuse	P	18	9	0(2)	0	0(2)	0
N.C:	Charlotte[c]	P	16	15	0(4)	0	15(4)	12
N. Dak:	Minot[c]	P	11	11	0(4)	0	14(4)	14
Ohio:	Cincinnati[c]	P	9	9	0(4)	0	7(4)	6
	Cleveland[c]	P	9	9	0(4)	0	6(4)	8
Okla:	Oklahoma City[c]	P	7	10	0(4)	0	12(4)	7
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	3	7	0(4)	0	0(4)	14
	Baker	P	NA	3	(e)	(e)	18	5
	Coos Bay	P	NA	10	(e)	(e)	30	15
	Eugene	P	NA	4	(e)	(e)	(e)	14
	Medford	P	NA	2	(e)	(e)	(e)	10
	Portland composite	P	NA	5	(e)	(e)	(e) (4)	8
	Portland local	P	NA	5	(e)	(e)	(e) (4)	9
	Redmond	P	NA	2	(e)	(e)	(e)	6
	Tillamook	R	NA	8	(e)	(e)	25	27
Pa:	Philadelphia[c]	P	8	10	0(4)	0	7(4)	8
	Pittsburgh[c]	P	12	12	0(4)	0	7(4)	11
	Dauphin	P	7	7	0	0	20	16
	Erie	P	10	13	0	0	17	22
	Philadelphia	P	8	10	0	0	0(2)	16
	Pittsburgh	P	14	12	0	0	14	16
R.I:	Providence[c]	P	8	11	0(4)	0	15(4)	19
S.C:	Charleston[c]	P	12	14	0(4)	0	20(4)	25
S. Dak:	Rapid City[c]	P	4	9	0(4)	0	6(4)	10
Tenn:	Chattanooga[c]	P	11	13	0(4)	0	16(4)	13
	Memphis[c]	P	5	11	0(4)	0	13(4)	6
	Chattanooga	P	11	11	0(4)	0	22(4)	17
	Clinton	P	12	13	0(2)	0	19(2)	19
	Knoxville	P	7	10	0(2)	2	12(2)	14
	Nashville	P	8	9	0(2)	0	0(2)	10
Tex:	Austin[c]	P	0	3	0(4)	0	0(4)	2
	Dallas[c]	P	6	8	0(4)	0	10(4)	8
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	3	4	0	0	0	2
	El Paso	R	2	2	0	0	0	0
	Fort Worth	R	NS	6	NS	0	NS	7
	Harlingen	R	NS	4	NS	0	NS	0
	Houston	R	NS	10	NS	0	NS	19
	Lubbock	R	3	4	0	0	0	2
	Midland	R	NS	3	0	0	0	0
	San Antonio	R	NS	3	NS	0	NS	0
	Texarkana	R	NS	12	NS	0	NS	16
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	6	9	0	0	10	2
Utah:	Salt Lake City[c]	P	6	5	0(4)	0	6(4)	11
Vt:	Burlington[c]	P	9	10	0(4)	0	15(4)	10
Va:	Norfolk[c]	P	10	11	0(4)	0	10(4)	10
Wash:	Seattle[c]	P	8	8	0(4)	0	14(4)	21
	Spokane[c]	P	6	6	0(4)	0	5(4)	10
	Benton County	R	NS	0	NS	0	NS	6
	Franklin County	R	0	0	0	0	0	0
	Sandpoint, Idaho	R	9	9	0	0	16	25
	Skagit County	R	5	5	0	0	0	13
W.Va:	Charleston[c]	P	7	12	0(3)	0	10(3)	6
Wisc:	Milwaukee[c]	P	7	7	0(4)	0	16(4)	11
Wyo:	Laramie[c]	P	6	4	0(3)	0	13(3)	11
CANADA								
Alberta:	Calgary	P	8	8	(d)		13	18
	Edmonton	P	7	8	(d)		14	20
British Columbia:	Vancouver	P	12	14	(d)		33	49
Manitoba:	Winnipeg	P	5	8	(d)		25	25
New Brunswick:	Fredericton	P	13	15	(d)		15	23
Newfoundland:	St. Johns	R	16	20	(d)		26	42
Nova Scotia:	Halifax	R	10	12	(d)		13	22
Ontario:	Ft. William	P	15	16	(d)		25	31
	Ottawa	P	9	9	(d)		15	19
	Sault Ste. Marie	P	16	15	(d)		32	33

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for February 1969 and 12-month period, March 1968 through February 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
Ontario:	Toronto	P	5	5	([d])		13	15
	Windsor	P	6	6	([d])		10	13
Quebec:	Montreal	P	7	9	([d])		19	21
	Quebec	P	11	12	([d])		25	29
Saskatchewan:	Regina	P	7	7	([d])		15	17
	Saskatoon	P	9	0	([d])		14	18
CENTRAL AND SOUTH AMERICA								
Columbia:	Bogota	P	NS	1	NS	0	NS	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	NA	0	0	0	0	0
Jamaica:	Mandeville	P	3	6	0	0	40	105
Venezuela:	Caracas	P	0	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	2	0(4)	1	15(4)	12
Puerto Rico:	San Juan[c]	P	4	5	0(4)	0	3(4)	9
PMN network averages[f]			7	9	0	0	10	12

[a] P, pasteurized milk; R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [c].

NA no analysis.

NS, no sample collected.

the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for February 1969 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which barium-140 was detected.

Table 4. Barium-140 in milk, February 1969

Sampling location		Monthly average (pCi/liter)
		Barium-140
Calif:	Humboldt (State)	20
	Los Angeles (State)	13
	Mendocino (State)	13
	Sacramento (State)	15
	Shasta (State)	13

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for the month of February 1969 and the highest 12-month average was 20 pCi/liter (Little Rock, Ark., New Orleans, La., and Duluth, Minn.) representing 10.0 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 108 pCi/liter in the United States for the month of February 1969 and the highest 12-month average was 14 pCi/liter (Southeast Fla.), representing 3.2 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level.

Acknowledgment

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational, and
Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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FOOD AND DIET SURVEILLANCE

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	January–March 1968	October 1968
Connecticut Diet Study	January–June 1968	November 1968
Institutional Diet, *PHS*	July–September 1968	April 1969
Tri-City Diet, *HASL*	January–June 1968	April 1969

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below:

Water sampling program	Period reported	Last presented
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Drinking Water Analyses Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
Minnesota	January–June 1968	February 1969
New York	January–June 1968	April 1969
Radiostrontium in Tap Water, HASL	January–June 1967	April 1969
Washington	July 1966–June 1967	August 1968

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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Radioactivity in Washington Surface Water[1], July 1967-June 1968

Washington State Department of Health

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Most surface water samples are collected quarterly or semiannually by the Washington State Pollution Control Commission. Selected stations on the Columbia River are sampled weekly or monthly by local health departments. Cedar River, a major water supply for the greater Seattle area, is sampled monthly by the City of Seattle Water Department.

All surface water samples are collected as grab samples in 2-liter polyethylene bottles. To prevent loss of radioactivity to the container, 2 milliliters of concentrated nitric acid are added to the sample before shipment to the State laboratory in Seattle for analysis.

Analytical procedures

Surface water samples are divided into two groups; those samples coming from the Columbia River, and those samples coming from waters other than the Columbia River. The latter samples are placed in stainless-steel Marinelli beakers for gamma-ray spectroscopy analysis as soon after receipt as possible. Distilled water is added when

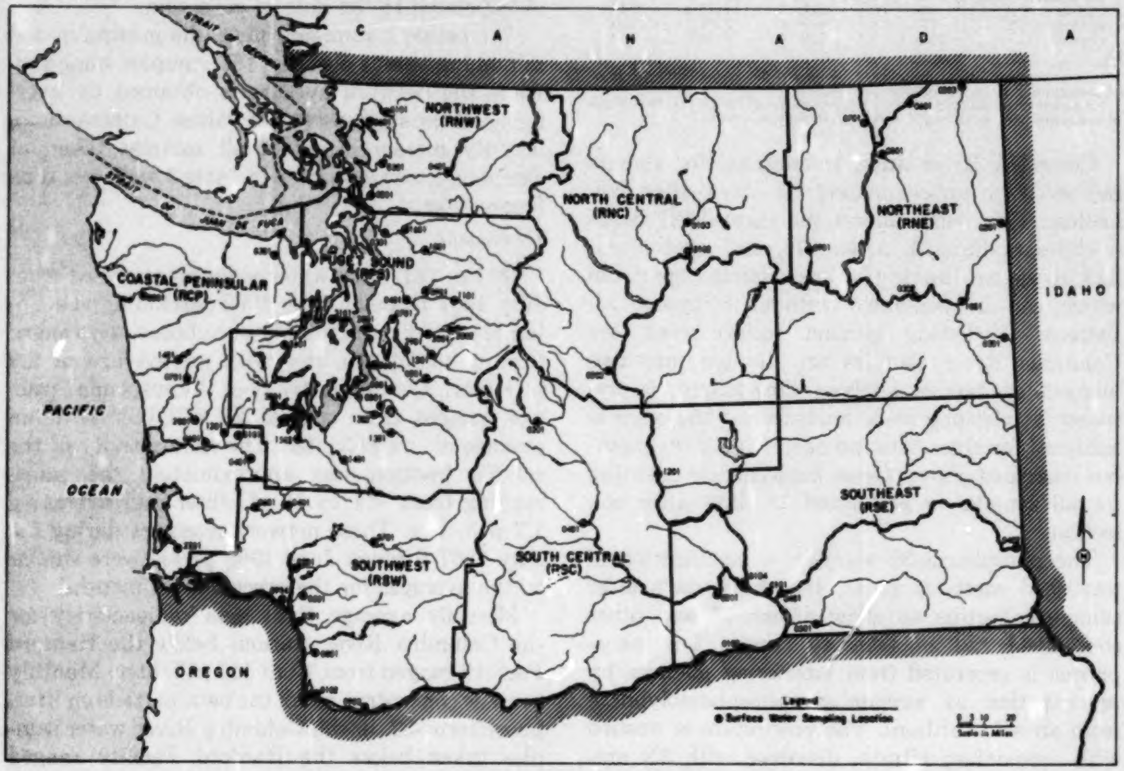
C A N A D A
STRAIT OF GEORGIA
STRAIT OF JUAN DE FUCA
NORTHWEST (RNW)
NORTH CENTRAL (RNC)
NORTHEAST (RNE)
IDAHO
COASTAL PENINSULAR (RCP)
PUGET SOUND (RPS)
PACIFIC
OCEAN
SOUTHWEST (RSW)
SOUTH CENTRAL (RSC)
SOUTHEAST (RSE)
OREGON
Legend
● Surface Water Sampling Location
Scale in Miles

Figure 1. Washington surface water sampling locations with code numbers

necessary to obtain a standardized counting geometry of 2 liters. Table 1 gives the gamma-ray efficiencies and detection limits for the gamma-ray spectrometer. After gamma-ray analysis, the samples are filtered through Whatman No. 42 filter paper. The filter paper containing the suspended solids is ashed in a muffle furnace, transferred to a tared planchet, weighed, and counted for gross beta radioactivity. The filtrate is evaporated to near dryness, quantitatively transferred to a tared planchet, dried, weighed, and counted for gross beta radioactivity.

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[1] Summarized from "Environmental Radiation Surveillance, Quarterly Reports and Sixth Annual Report."

Table 1. Beta-particle and gamma-ray efficiencies and detectability limits for the Washington State analysis

Radionuclide	Energy band (MeV)	Efficiency (percent)	Average background (cpm)	Detectability limits (pCi)
Beta-particle emitters:				
Strontium-90-yttrium-90		34	0.5	[a] 0.31
Yttrium-90		38	.5	[a] .28
Phosphorus		35	.5	[a] .30
Gamma-ray emitters:				
Chromium-51	0.30-0.36	0.52	22.18	[b] 200
Ruthenium-106	.44- .56	.91	22.36	[b] 100
Cesium-137	.62- .72	2.75	11.18	[b] 30
Zirconium-95	.73- .79	6.96	5.72	[b] 10
Zinc-65	1.06-1.17	1.06	6.38	[b] 40

[a] Amount of radiation necessary to produce a net cpm equal to 2 sigma of background, based on 100 minute counts.

[b] Amount of radiation necessary to produce a net cpm equal to 4 sigma of the respective background, based on 100 minute counts.

Columbia River water is analyzed for gamma radioactivity approximately 14 days after collection. This delay allows the short-lived radionuclides, sodium-24, arsenic-76, and neptunium-239 to decay, leaving a less complex spectrum which can be evaluated without computer assistance. Following gamma radioanalysis the Columbia River samples are divided into two aliquots for further analysis. One aliquot is prepared for phosphorus-32 analysis and the other is analyzed for gross beta radioactivity by the methods described above. Gross beta-particle counting for all samples is performed 18 days after collection.

The phosphorus-32 analysis, a modification of published methods (*1-4*), begins 15 days after sample collection to allow arsenic-76 and other short-lived radionuclides to decay. The phosphorus is separated from interfering nuclides by precipitation as ammonium phosphomolybdate from an acid medium. The precipitate is washed with ammonium nitrate, dissolved with 3N ammonium hydroxide, transferred to a tared planchet, dried, ashed at 450°C., and counted for beta radioactivity.

Results

Table 2 presents the monthly average results for seven Columbia River stations which are sampled routinely. In averaging, a less than value is assumed to be equal to its numerical value and a less-than sign is placed in front of the average.

Table 3 summarizes the beta radioactivity measurements from 27 other surface water stations from July 1967 through June 1968. The second column in this table gives code numbers and the abbreviations denoting geographical sections (figure 1). Each river is assigned a four digit number; the first two digits indicate the river and the second two digits indicate the sampling stations on the river. For example, code number 04 refers to the Snake River in the area designated "RSE", i.e., Southeast. The code number 01 refers to the first sampling station on that river. The third column gives the total number of samples analyzed. Gross beta radioactivity results are not extrapolated to the date of collection.

The network summary gives the maximum and minimum values for the 161 samples analyzed, while the network average is obtained by averaging all the station average values. Gamma radioactivity measurements of all samples taken at sampling locations shown in table 3 were less than 5 cpm/liter.

Discussion

Of the 161 river water samples analyzed from July 1967 through June 1968 (excluding the Columbia River), the total beta radioactivity ranged from 1 to 32 pCi/liter with an average of 2.9 pCi/liter. The radioactivity of the suspended fraction ranged from <1 to 28 pCi/liter with an average of <1 pCi/liter. The radioactivity of the soluble fraction was approximately the same, ranging from <1 to 10 pCi/liter and averaging 1.7 pCi/liter. These network averages during the July 1967 through June 1968 period were similar to the averages for the preceding 12 months.

Monthly average total beta radioactivity for the Columbia River stations below the Hanford Facility ranged from 10 to 545 pCi/liter. Monthly average concentrations of the beta-particle emitter, phosphorus-32, in the Columbia River water samples taken below the Hanford Facility ranged from 5 to 317 pCi/liter.

Table 2. Monthly average radioactivity in Columbia River water, July 1967–June 1968

Location and type of analysis	Concentration (pCi/liter)											
	1967						1968					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
McNary Dam (code No. RSE 0107)												
Beta-particle												
Suspended[a]	15	16	NS	6	16	NS	20	14	19	19	65	17
Dissolved[a]	35	30	NS	56	48	NS	43	55	56	50	79	15
Total[a]	50	46	NS	62	64	NS	63	69	75	69	144	32
Phosphorus-32[b]	41	NA	NS	66	47	NS	43	34	61	66	133	13
Gamma-ray[b]												
Chromium-51	1,236	1,223	NS	2,434	1,440	NS	1,574	913	1,109	898	1,617	211
Ruthenium-106[c]	<50	<50	NS	<50	<50	NS	<50	<50	<50	<50	<50	<50
Zirconium-95	<5	<5	NS	<5	<5	NS	<5	<5	<5	<5	<5	<5
Zinc-65	37	25	NS	25	<20	NS	51	36	73	42	56	25
Scandium-46	17	13	NS	23	35	NS	45	32	60	25	93	27
Northport (code no. RNE 0801)												
Beta-particle												
Suspended[a]	NS	<1	NS	NS	NS	<1	NS	NS	<1	NS	<1	NS
Dissolved[a]	NS	2	NS	NS	NS	3	NS	NS	2	NS	2	NS
Total[a]	NS	<3	NS	NS	NS	<4	NS	NS	<3	NS	<3	NS
Phosphorus-32[b]	NS	<1	NS	NS	NS	<1	NS	NS	<1	NS	<1	NS
Gamma-ray[b]												
Chromium-51	NS	<100	NS	NS	NS	<100	NS	NS	<100	NS	<100	NS
Ruthenium-106[c]	NS	<50	NS	NS	NS	<50	NS	NS	<50	NS	<50	NS
Zirconium-95	NS	<5	NS	NS	NS	<5	NS	NS	<5	NS	<5	NS
Zinc-65	NS	<20	NS	NS	NS	<20	NS	NS	<20	NS	<20	NS
Scandium-46	NS	<10	NS	NS	NS	<10	NS	NS	<10	NS	<10	NS
Richland (code no. RSE 0104)												
Beta-particle												
Suspended[a]	38(2)	250(2)	31(2)	47(2)	997	40	35(2)	36(2)	42	37(2)	142(2)	27(2)
Dissolved[a]	66(2)	134(2)	95(2)	129(2)	258	178	139(2)	186(2)	179(2)	163	125(2)	54(2)
Total[a]	104	384	126	176	545	218	174	222	221	200	267	81
Phosphorus-32[b]	46(2)	193	79(2)	91(2)	168	91	103(2)	163(2)	109(2)	129(2)	209(2)	45(2)
Gamma-ray[b]												
Chromium-51	2,012(2)	4,492(2)	3,130(2)	5,904(2)	7,346	5,890	3,102(2)	3,023(2)	2,823(2)	1,347(2)	2,331(2)	947(2)
Ruthenium-106[c]	<100(2)	<100(2)	<100(2)	<100(2)	<100	<100	<100(2)	<100(2)	<100(2)	<100(2)	<100(2)	<100(2)
Zirconium-95	<10(2)	<14(2)	<10(2)	<10(2)	<10(2)	<10	<10(2)	<10(2)	<10(2)	<10(2)	<10(2)	<10(2)
Zinc-65	73(2)	207(2)	58(2)	155(2)	339	128	114(2)	142(2)	145(2)	99(2)	169(2)	51(2)
Scandium-46	69(2)	194(2)	79(2)	88(2)	499	126	99(2)	99(2)	257(2)	89(2)	165(2)	68(2)
Pasco (code no. RSE 0101)												
Beta-particle												
Suspended[a]	26	59	114	107	41	72	73	38	71	52	219	62
Dissolved[a]	31	70	95	195	94	104	122	137	163	134	217	96
Total[a]	57	129	209	303	135	176	197	175	234	186	436	158
Phosphorus-32[b]	13	45	90	182	79	98	140	149	212	203	317	150
Gamma-ray[b]												
Chromium-51	1,004	2,979	4,437	5,570	2,771	3,145	3,832	1,792	2,743	1,782	4,808	1,393
Ruthenium-106[c]	73	<50	102	149	58	<50	<50	73	98	<50	107	<50
Zirconium-95	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zinc-65	41	107	122	134	84	97	117	79	127	103	164	85
Scandium-46	17	79	111	129	95	105	167	100	135	84	194	93
Wanapum Dam (code no. RSC 1201)												
Beta-particle												
Suspended[a]	<1	<1	<1	<1	<1	NS	<1	<1	NS	NS	NS	NS
Dissolved[a]	2	2	2	2	2	NS	2	3	NS	NS	NS	NS
Total[a]	<3	<3	<3	<3	<3	NS	<3	<4	NS	NS	NS	NS
Phosphorus-32[b]	<1	<1	<1	<1	<1	NS	<1	<1	NS	NS	NS	NS
Gamma-ray[b]												
Chromium-51	<100	<100	<100	<100	<100	NS	<100	<100	NS	NS	NS	NS
Ruthenium-106[c]	<50	<50	<50	<50	<50	NS	<50	<50	NS	NS	NS	NS
Zirconium-95	<5	<5	<5	<5	<5	NS	<5	<5	NS	NS	NS	NS
Zinc-65	<20	<20	<20	<20	<20	NS	<20	<20	NS	NS	NS	NS
Scandium-46	<10	<10	<10	<10	<10	NS	<10	<10	NS	NS	NS	NS
Vancouver (code no. RSW 0102)												
Beta-particle												
Suspended[a]	21(4)	15	8(3)	6(3)	11(3)	31(2)	23(2)	14	NS	18(4)	24(3)	13(2)
Dissolved[a]	24(4)	22	24(3)	29(3)	25(3)	29(2)	21(2)	43	NS	25(4)	37(3)	15(2)
Total[a]	45	37	32	35	36	50	44	57	NS	42	61	28
Phosphorus-32[b]	23(4)	19	13(3)	18(3)	25(3)	25(2)	19(2)	41	NS	27(4)	54(3)	18(2)
Gamma-ray[b]												
Chromium-51	1,032(4)	1,325	1,082(3)	1,300(3)	1,300(3)	1,337(2)	770(2)	1,132	NS	421(4)	880(3)	281(2)
Ruthenium-106[c]	<50(4)	<50	<50(3)	<50(3)	<50(2)	<50(2)	<50(2)	<50	NS	<50(4)	<50(3)	<50(2)
Zirconium-95	<5(4)	<5	<5(3)	<5(3)	<5(2)	<5(2)	<5(2)	<5	NS	<5(4)	<5(3)	<5(2)
Zinc-65	30(4)	<20	<25(3)	<20(3)	<26(2)	<26(2)	23(2)	24	NS	<23(4)	31(3)	<20(2)
Scandium-46	19(4)	11	<10(3)	<10(3)	<12(2)	32(2)	30(2)	34	NS	32(4)	26(3)	24(2)
Longview (code No. RSW 0904)												
Beta-particle												
Suspended[a]	10(4)	6(5)	7(4)	7(4)	7(5)	4(4)	6(5)	4(6)	7(4)	7(2)	13(3)	11(4)
Dissolved[a]	14(4)	15(5)	17(4)	22(4)	15(5)	6(4)	10(3)	7(6)	15(4)	10(2)	20(5)	10(4)
Total[a]	24	21	24	29	22	10	16	11	22	17	33	21
Phosphorus-32[b]	14(4)	11(3)	10(4)	12(4)	14(5)	5(4)	9(5)	6(4)	20(4)	11(2)	25(5)	12(4)
Gamma-ray[b]												
Chromium-51	575(4)	917(5)	1,330(4)	1,046(4)	769(5)	279(4)	<345(5)	162(4)	365(4)	176(2)	486(5)	191(4)
Ruthenium-106[c]	<50(4)	<50(4)	<50(4)	<50(5)	<50(5)	<50(4)	<50(5)	<50(4)	<50(4)	<50(2)	<50(5)	<50(4)
Zirconium-95	<5(4)	<5(5)	<6(4)	<5(4)	<5(5)	<5(4)	<5(5)	<5(4)	<5(4)	<5(2)	<5(5)	<5(4)
Zinc-65	<20(4)	<26(5)	<22(4)	<20(4)	<21(5)	<20(4)	<20(5)	<21(4)	<20(4)	<20(2)	<23(5)	<20(4)
Scandium-46	<11(4)	<10(5)	<10(4)	<11(4)	<10(5)	<10(4)	<11(5)	<10(4)	<12(4)	13(2)	<11(5)	<14(4)

[a] Activity at time of counting. Strontium-90 yttrium-90 calibration standard.
[b] Results extrapolated to date of sample collection.
[c] Net activity in the 0.44–0.56 MeV gamma-range is assumed to be only ruthenium-106.

NS, no sample reported.

Table 3. Beta radioactivity in Washington surface water (except for Columbia River) July 1967–June 1968

Sampling location	Code number	Number of samples	Concentration (pCi/liter)								
			Suspended			Dissolved			Total		
			Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum
Cedar River	RPS [illegible]	12	<1	<1	<1	<1	<1	2	1	1	3
Colville River	RNE [illegible]	1	<1			4			5		
Kettle River	RNE [illegible]	1	<1			1			2		
Klickitat River	RSC [illegible]	7	<1	<1	2	1	1	2	2	2	4
Lake Whatcom	RNW [illegible]	9	<1	<1	1	3	2	4	4	3	5
Lewis River	RSW [illegible]	11	<1	<1	1	<1	<1	1	1	1	3
Little Spokane River	RNE [illegible]	1	<1			2			3		
Naches River	RSC [illegible]	11	<1	<1	<1	1	<1	2	2	1	3
Naselle River	RCP [illegible]	10	<1	<1	<1	<1	<1	2	1	1	3
Nisqually River	RPS 1401	5	1	<1	2	1	1	2	2	2	4
Nooksack River	RNW 0101	4	2	<1	4	2	1	2	4	2	6
Okanogan River	RNC [illegible]	4	1	<1	2	2	2	3	3	2	5
Pend Oreille River	RNE [illegible]	11	<1	<1	1	2	2	3	3	2	4
Puyallup River	RPS [illegible]	11	6	<1	28	2	1	4	6	2	32
Satsop River	RCP [illegible]	2	<1	<1	<1	<1	<1	1	1	1	2
Skagit River	RNW [illegible]	12	<1	<1	2	2	1	2	3	2	4
Snake River	RSE [illegible]	8	1	<1	6	4	2	5	5	2	11
Snohomish River	RPS [illegible]	3	<1	<1	1	1	1	2	2	2	3
Snoqualmie River, South Fork	RPS [illegible]	1	<1			1			2		
Spokane River	RNE 0301	7	1	<1	5	2	1	3	3	2	8
Sultan River	RPS [illegible]	3	<1	<1	<1	2	1	2	3	2	3
Tolt River	RPS [illegible]	3	<1	<1	<1	<1	<1	1	1	1	2
Toutle River	RSW 0301	4	<1	<1	<1	1	1	1	2	2	2
Walla Walla River	RSE 0801	3	3	<1	7	6	4	10	9	5	17
Wenatchee River	RNC [illegible]	4	<1	<1	<1	2	2	2	3	3	3
Wishkah River	RCP 2201	9	<1	<1	1	<1	<1	1	1	1	2
Yakima River	RSC 0501	4	<1	<1	<1	<1	<1	1	1	1	2
Network summary		161	<1	<1	28	1.7	<1	10	2.9	1	32

[a] For averaging purposes, <1 is assumed to be equal to 0.5 pCi/liter. Averages less than 1 are recorded as <1.

The gamma-ray emitters, ruthenium-106 and zirconium-95, were found in monthly average concentrations that ranged from <50 to 149 pCi/liter for ruthenium-106, and <5 to <14 pCi/liter for zirconium-95. The values for ruthenium-106 were probably a combination of ruthenium-103 and ruthenium-106. Other radionuclides found in detectable quantities in Columbia River water were chromium-51, zinc-65, and scandium-46. Monthly averages for chromium-51 ranged from <100 to 7,346 pCi/liter, for zinc-65 the range was <20 to 339 pCi/liter, while scandium-46 ranged from <10 to 499 pCi/liter.

Although any standards for gross beta radioactivity must be very carefully applied, the standard for drinking water is 1,000 pCi/liter of gross beta radioactivity in the absence of strontium-90 and alpha-particle emitters (*5*). The standards for water from all dietary sources for the general population at large (*6*) are: chromium-51, 670,000 pCi/liter; ruthenium-106, 3,300 pCi/liter; zinc-65, 10,000 pCi/liter; phosphorus-32, 7,000 pCi/liter; and scandium-46, 13,000 pCi/liter.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1965–June 1966	August 1967
July 1966–June 1967	August 1968

REFERENCES

(*1*) KOLTHOFF and SANDELL. Textbook of Quantitative Inorganic Analysis, Revised Edition. The MacMillan Company, New York, N.Y. (1949) pp. 390–397; 713–717.

(*2*) HILLEBRAND, W. F., G. LUNDELL. Applied Inorganic Analysis. John Wiley and Sons, Inc., New York, N.Y. (1953) pp. 694–710.

(*3*) FURMAN, N. H. Scotts' Standard Method of Analysis, 5th Edition, Vol. 1. Van Nostrand Company, Inc., New York, N.Y. (1944) pp. 694–697.

(*4*) HANFORD ATOMICS PRODUCTS OPERATIONS. Radiological chemical analysis: River analysis manual-phosphorus-32 determination. Hanford Facility, Richland, Wash.

(*5*) PUBLIC HEALTH SERVICE. Public Health Service drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (August 1963).

(*6*) INTERNATIONAL COMMISSION OF RADIOLOGICAL PROTECTION. Report of Committee II on Permissible Dose for Internal Radiation. Pergamon Press, New York, N.Y. (1959).

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Tritium in Surface Water Network, July-December 1968

Bureau of Radiological Health
U.S. Public Health Service

The tritium sampling network was established by the Public Health Service in May 1964 to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at selected surface water stations downstream from nuclear facilities. The network consists of 10 stations selected from the 131 existing water pollution sampling stations operated by the Federal Water Pollution Control Administration (FWPCA); eight of the stations are located downstream from nuclear facilities and two stations serve to establish baseline levels (figure 1). Reports covering the period, 1964–1965 (*1*) and 1966 (*2*) have been published previously in *Radiological Health Data and Reports.*

Monthly composites of weekly samples are collected through the FWPCA and sent to the Southeastern Radiological Health Laboratory for analysis. The analyses are carried out using liquid scintillation counting techniques described by Moghissi et al (*3*). The minimum level of detectability is 0.2 nCi/liter.

Data for the samples collected during the last 6 months of 1968 are shown in table 1. Station

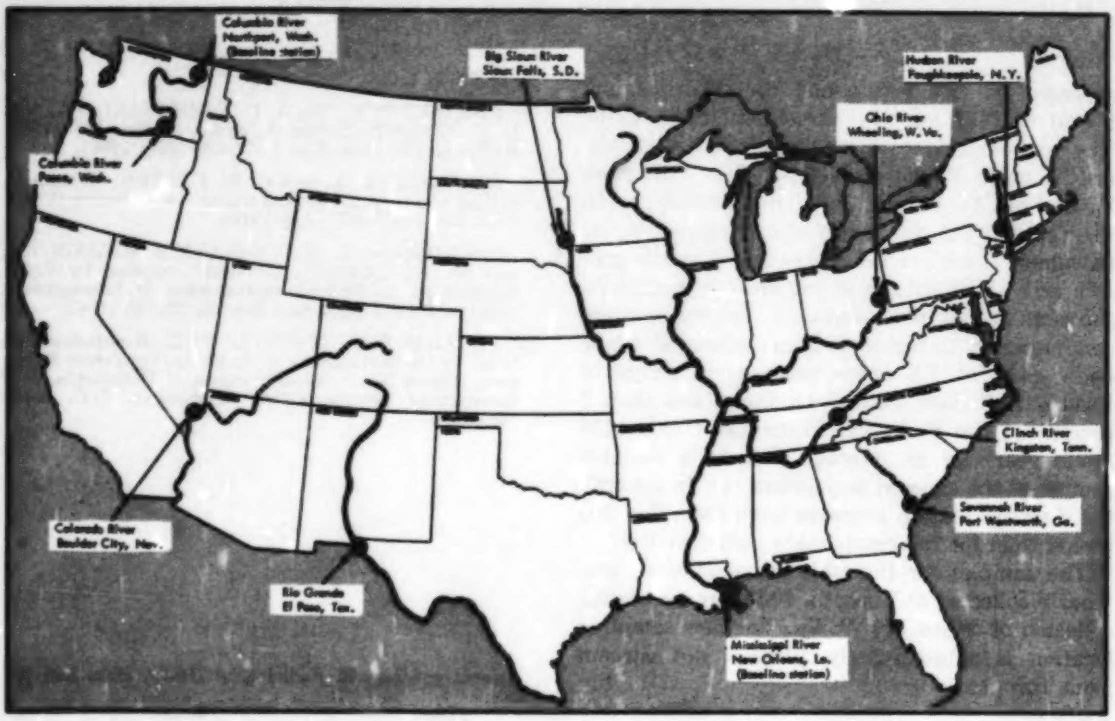
Columbia River
Northport, Wash.
(Baseline station)
Big Sioux River
Sioux Falls, S.D.
Hudson River
Poughkeepsie, N.Y.
Ohio River
Wheeling, W. Va.
Columbia River
Pasco, Wash.
Clinch River
Kingston, Tenn.
Savannah River
Port Wentworth, Ga.
Colorado River
Boulder City, Nev.
Rio Grande
El Paso, Tex.
Mississippi River
New Orleans, La.
(Baseline station)

Figure 1. Sampling stations for tritium in surface waters

Table 1. Tritium concentration in surface waters, July–December 1968

Collection site	Concentration[a] (nCi/liter)							
	July	August	September	October	November	December	July–December average[b]	
							1968	1967
Big Sioux River: Sioux Falls, S.Dak.	0.3±0.2	0.4±0.2	0.3±0.2	NS	NS	NS	0.3	0.8
Clinch River: Kingston, Tenn.	4.1±0.3	.4±0.2	.6±0.2	NS	NS	NS	1.7	5.4
Colorado River: Boulder City, Nev.	NS	2.0±0.2	1.7±0.2	NS	NS	1.6±0.2	1.8	2.3
Columbia River: Northport, Wash[d]	NS	NS	NS	NS	0.8±0.2	NS		
Columbia River: Pasco, Wash.	.9±0.2	NS	.9±0.2	NS	.6±0.2	NS	.8	1.1
Hudson River: Poughkeepsie, N.Y.	.6±0.2	[c].2±0.2	.8±0.2	NS	.4±0.2	NS	.5	.8
Mississippi River: New Orleans, La[d]	.8±0.2	.4±0.2	.5±0.2	NS	NS	NS	.6	.6
Ohio River: Wheeling, W.Va.	NS	NS	NS	NS	NS	.2±0.2		
Rio Grande: El Paso, Tex.	NS	NS	NS	NS	NS	[c].2±0.2		.3
Savannah River: Port Wentworth, Ga.	8.9±0.4	5.9±0.3	5.8±0.5	NS	NS	NS	6.9	5.6

[a] The error reported is the 2-sigma counting error.
[b] Values less than or equal to the minimum level of detectability (0.2 nCi/liter) were averaged as zero.
[c] Values are not statistically significant at the 95-percent confidence level.
[d] Baseline station.

averages for this period and the corresponding period of 1967 are also presented in the table. The highest concentration observed during the last 6 months of 1968 was 8.9 nCi/liter (Savannah River–Port Wentworth, Ga.). The highest 6-month average, 6.9 nCi/liter, was also observed at the Savannah River station. Assuming that the specific activity of tritium in the body is essentially the same as that in the surface water, this average concentration corresponds to an estimated whole body dose[1] of 1.2 mrem/year; or in terms of Federal Radiation Council guidance, less than 1 percent of the Radiation Protection Guide (170 mrem/year) for an average dose to a suitable sample of the exposed population (4). In general, the 6-month station averages were lower for this period than for the comparable period in 1967.

The samples for the Ohio River station, previously collected at Toronto, Ohio, are now being collected at Wheeling, W. Va. The new sampling location is approximately 50-miles downstream from Toronto.

REFERENCES

(*1*) CHESNUTT, M. W., J. C. DROBINSKI, JR., and R. H. GORRIE. Tritium in surface waters, 1964–1965. Radiol Health Data Rep 7:377–380 (July 1966).

(*2*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 7:337–339 (July 1968).

(*3*) MOGHISSI, A. A., H. L. KELLEY, J. E. REGNIER, and M. W. CARTER. Low-level counting by liquid scintillation. 1. Tritium measurement in homogeneous systems. Inter J Appl Rad Isotopes 20:145 (1969).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

Recent coverage in Radiological Health Data and Reports:

Period	Issue
January–December 1967	October 1968
January–June 1968	November 196

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[1] Development of the calculations to obtain this dose may be found in reference 2.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network
February 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during February 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

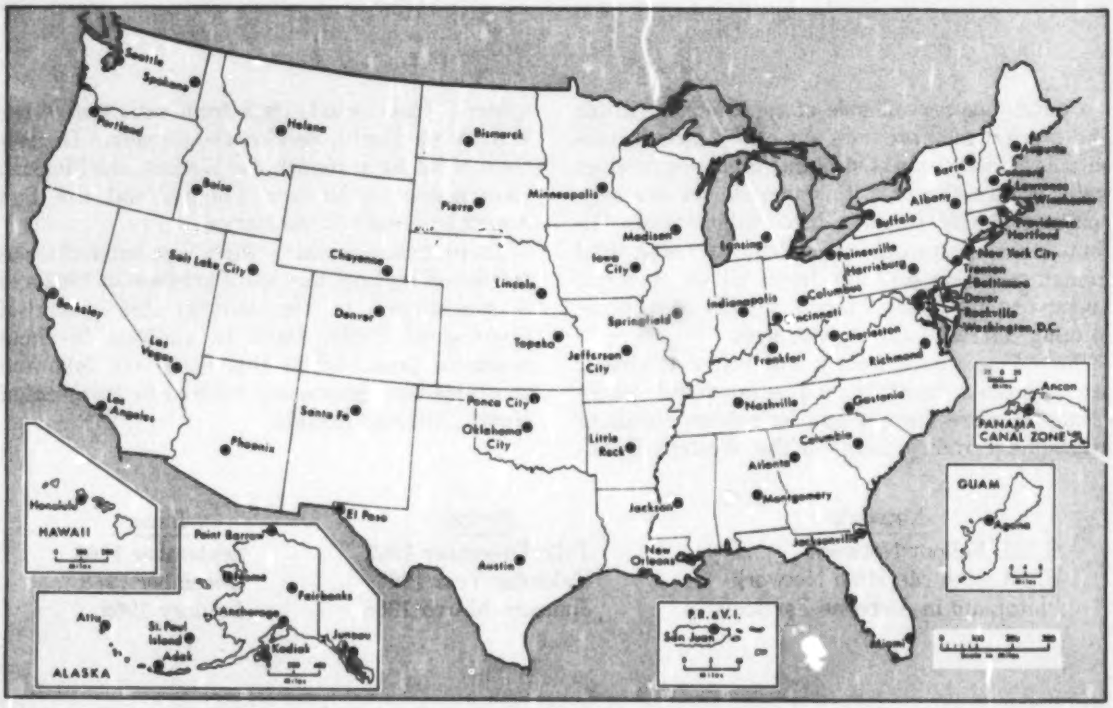
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Salt Lake City
Cheyenne
Iowa City
Lincoln
Berkeley
Denver
Springfield
Indianapolis
Columbus
Cincinnati
Topeka
Jefferson City
Frankfort
Charleston
Richmond
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Little Rock
Columbia
Atlanta
Phoenix
Montgomery
Jackson
El Paso
New Orleans
Jacksonville
Austin
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
ALASKA
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Providence
Hartford
Buffalo
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan
Scale in Miles
Miles

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, February 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average [a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	4	0	1	Sept 68	5	103	5	103	24
Alaska:	Adak	25	2	1	2	Feb 69	(c)				
	Anchorage	7	0	0	0	Oct 68	1	1	(d)		
	Attu Island	3	0	0	0	Mar 69	(c)				
	Fairbanks	(b)				Nov 68	(c)				
	Juneau	8	0	0	0	Dec 68	5	23	5	23	0
	Kodiak	5	0	0	0	Jan 69	(c)				
	Nome	(b)				May 69	(c)				
	Point Barrow	28	0	0	0	Apr 69	(c)				
	St. Paul Island	4	1	1	1	June 69	(c)				
Ariz:	Phoenix	17	12	1	5	Dec 68	(c)				
Ark:	Little Rock	10	4	0	1	Oct 68	(c)				
Calif:	Berkeley	19	1	0	0	Jan 69	13	198	13	198	0
	Los Angeles	4	1	0	0	May 69	(c)				
C.Z:	Ancon	15	0	0	0	Jan 69	(c)				
Colo:	Denver	18	10	1	4	Jan 69	(c)				
Conn:	Hartford	17	0	0	0	Nov 68	8	40	8	40	0
Del:	Dover	16	1	0	0	Sept 68	(c)				
D.C:	Washington	9	1	0	1	Apr 69	(c)				
Fla:	Jacksonville	12	2	0	1	Oct 68	3	25	3	25	22
	Miami	16	1	0	0	Nov 68	1	50	1	50	0
Ga:	Atlanta	19	1	1	1	June 69	2	50	2	50	74
Guam:	Agana	(b)				Sept 69	(c)				
Hawaii:	Honolulu	26	1	0	0	Mar 69	4	50	(d)		
Idaho:	Boise	22	2	0	0	Mar 69	8	62	8	62	83
Ill:	Springfield	17	1	0	0	Apr 69	(c)				
Ind:	Indianapolis	18	2	0	1	June 69	3	24	3	24	19
Iowa:	Iowa City	21	0	0	0	Jan 69	1	6	1	6	0
Kans:	Topeka	20	1	0	0	Oct 68	4	9	4	9	0
Ky:	Frankfort	12	1	0	1	Apr 69	(c)				
La:	New Orleans	18	1	0	0	Apr 69	8	95	(d)		
Maine:	Augusta	16	1	0	0	May 69	6	233	6	233	0
Md:	Baltimore	18	1	0	0	Nov 69	2	20	2	20	0
	Rockville	10	0	0	0	Mar 69	(c)				
Mass:	Lawrence	17	0	0	0	Jan 69	3	80	3	80	0
	Winchester	13	0	0	0	Feb 69	6	127	6	127	0
Mich:	Lansing	20	0	0	0	Mar 69	(c)				
Minn:	Minneapolis	10	0	0	0	Sept 68	1	2	1	2	0
Miss:	Jackson	19	1	0	0	May 69	3	92	3	92	50
Mo:	Jefferson City	18	1	0	0	June 69	6	48	6	48	0
Mont:	Helena	19	2	0	1	Feb 69	2	8	2	8	7
Nebr:	Lincoln	20	1	0	1	June 69	1	2	1	2	1
Nev:	Las Vegas	12	2	0	1	Nov 68	(c)				
N.H:	Concord	18	1	0	0	Apr 69	(c)				
N.J:	Trenton	20	0	0	0	May 69	4	63	4	63	29
N. Mex:	Santa Fe	12	2	0	1	Feb 69	4	6	2	6	4
N.Y:	Albany	12	2	0	1	June 69	5	28	5	28	38
	Buffalo	18	0	0	0	Jan 69	(c)				
	New York City	17	0	0	0	Feb 69	(c)				
N.C:	Gastonia	14	4	1	2	Jan 69	1	5	(d)		
N.Dak:	Bismarck	18	0	0	0	Apr 69	7	78	6	58	0
Ohio:	Cincinnati	(b)				Sept 68	(c)				
	Columbus	17	2	0	0	May 69	2	26	2	26	0
	Painesville	19	1	0	0	Nov 68	2	2	2	2	2
Okla:	Oklahoma City	18	2	0	1	Mar 69	4	75	4	75	0
	Ponca City	20	2	0	1	Nov 68	4	37	4	37	0
Ore:	Portland	18	1	0	0	June 69	6	52	6	52	17
Pa:	Harrisburg	14	0	0	0	June 69	(c)				
P.R:	San Juan	(b)				May 69	(c)				
R.I:	Providence	18	2	0	0	Mar 69	4	31	4	31	11
S.C:	Columbia	11	1	0	0	Feb 69	4	63	4	63	13
S. Dak:	Pierre	16	1	0	0	Dec 68	(c)				
Tenn:	Nashville	6	1	0	0	Mar 69	5	62	5	62	13
Tex:	Austin	14	7	0	2	Sept 68	3	88	(d)		
	El Paso	21	7	0	3	Apr 69	(c)				
Utah:	Salt Lake City	28	1	0	0	May 69	7	62	7	62	6
Vt:	Barre	15	1	0	0	Oct 68	8	59	7	58	0
Va:	Richmond	18	1	0	0	Oct 68	2	70	2	70	35
Wash:	Seattle	19	0	0	0	Oct 68	8	46	(d)		
	Spokane	18	0	0	0	Sept 68	1	3	1	3	3
W. Va:	Charleston	20	2	0	0	Feb 69	3	32	3	33	4
Wisc:	Madison	20	1	0	0	Oct 68	2	4	2	4	5
Wyo:	Cheyenne	20	6	1	3	Nov 68	2	8	2	8	15
Network summary		1,097	12	0	1		4	50	4	51	12

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] No report received. (Air samples received without field estimate data are not considered by the data program.)

[c] No precipitation sample collected.

[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

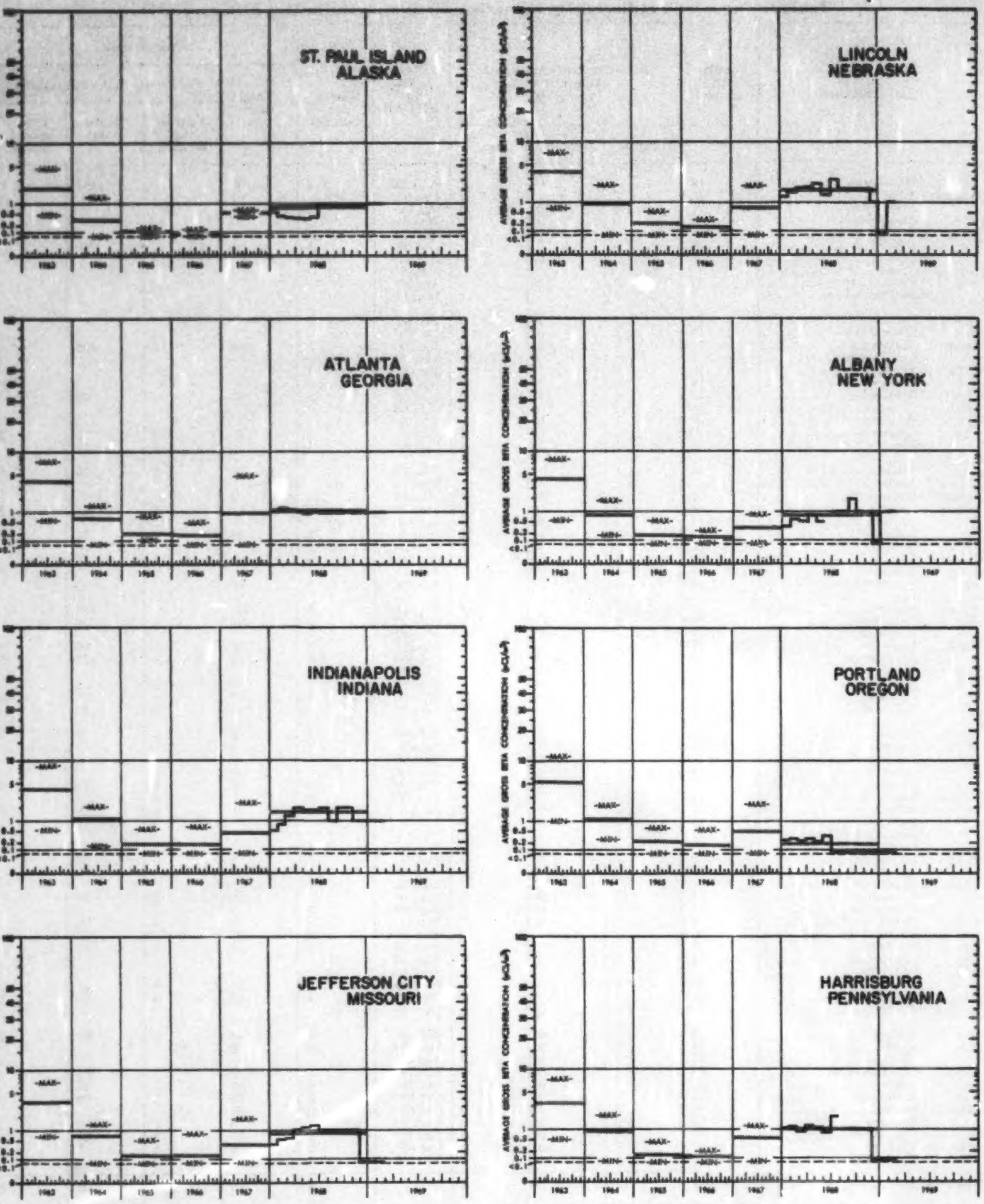

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network 1963–February 1969

2. Canadian Air and Precipitation Monitoring Program[1], February 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for February 1969 are presented in table 2.

The average deposition for 23 stations for January 1969 was 0.6 nCi/m² with a high of 1.5 nCi/m² occurring at Sault St. Marie and VanCouver and a low of 0.1 nCi/m² occurring at Resolute.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, February 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	28	0.2	0.0	0.1	NS	NS
Coral Harbour	28	.1	.0	.1	25	0.3
Edmonton	28	.1	.0	.1	21	.4
Ft. Churchill	27	.1	.0	.1	47	.2
Ft. William	28	.2	.0	.1	31	.4
Fredericton	28	.2	.0	.1	12	.6
Goose Bay	13	.1	.0	.1	68	2.5
Halifax	27	.1	.0	.1	13	1.2
Inuvik	28	.1	.0	.1	32	.3
Montreal	28	.1	.0	.1	15	.3
Moosonee	23	.1	.0	.1	4	.1
Ottawa	28	.2	.0	.1	6	.1
Quebec	28	.1	.0	.1	7	.2
Regina	28	.1	.0	.1	38	1.1
Resolute	26	.2	.0	.1	11	.1
St. John's, Nfld	26	.2	.0	.1	15	2.0
Saskatoon	28	.1	.0	.1	12	.2
Saulte Ste Marie	28	.1	.0	.1	15	.4
Toronto	28	.2	.0	.1	21	.3
Vancouver	28	.1	.0	.1	33	1.6
Whitehorse	28	.1	.0	.1	48	.3
Windsor	28	.1	.0	.1	60	.3
Winnipeg	28	.1	.0	.1	44	.4
Yellowknife	27	.2	.0	.1	21	.2
Network summary	27	0.1	0.0	0.1	26	0.6

NS, no sample.

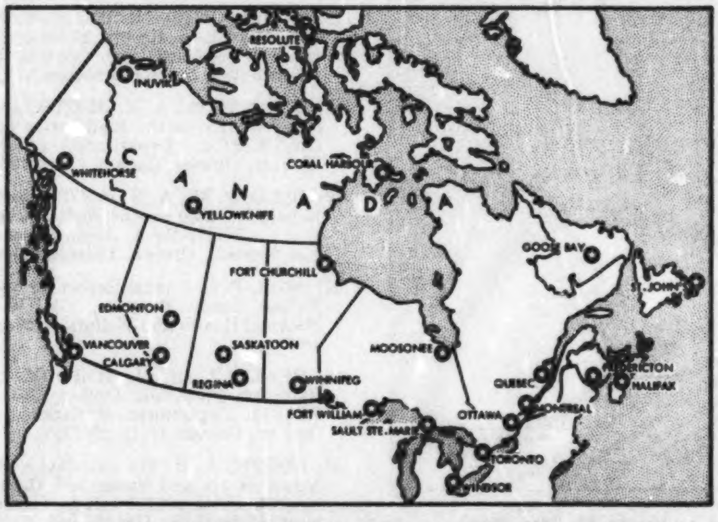
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
SAULT STE. MARIE
OTTAWA
MONTREAL
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the March 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Pan American Air Sampling Program February 1969

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The February 1969 air monitoring results from the participating countries are given in table 3.

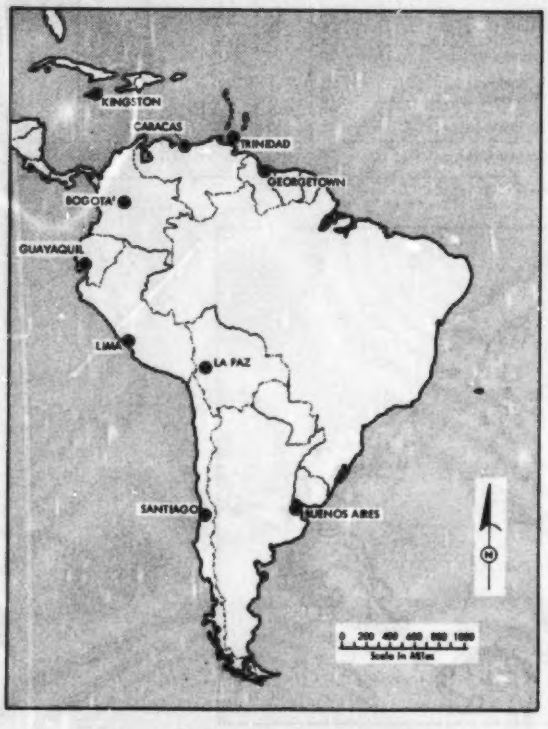

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, February 1969

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average ᵃ
Argentina: Buenos Aires	18	0.38	0.13	0.26
Bolivia: La Paz	11	.06	.00	.04
Chile: Santiago	2	.21	.13	.17
Colombia: Bogota	15	.07	.01	.03
Ecuador: Guayaquil	16	.17	.06	.11
Guyana: Georgetown	13	.11	.02	.06
Jamaica: Kingston	16	.16	.04	.10
Peru: Lima	NS			
Venezuela: Caracas	15	.09	.01	.05
West Indies: Trinidad	14	.10	.02	.05
Pan American summary	120	0.38	0.00	0.10

ᵃ The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no sample.

REFERENCES

(1) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. Bureau of Radiological Health, Office of Standards and Criteria, Rockville, Md. 20852 (Distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(4) MAR, P. G. Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Radionuclides in Alaskan Caribou and Reindeer, September-November 1968

Bureau of Radiological Health
U.S. Public Health Service

Under a cooperative agreement between the Alaskan Department of Health and Welfare, the Alaskan Department of Fish and Game, and the U.S. Public Health Service, an active program of caribou and reindeer sampling and analysis was undertaken in 1963 to aid in the assessment of radionuclide intake of Alaskan residents. This joint sampling activity was continued based on the results of a limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou herds and one privately-owned reindeer herd. This program was expanded in September 1964, when

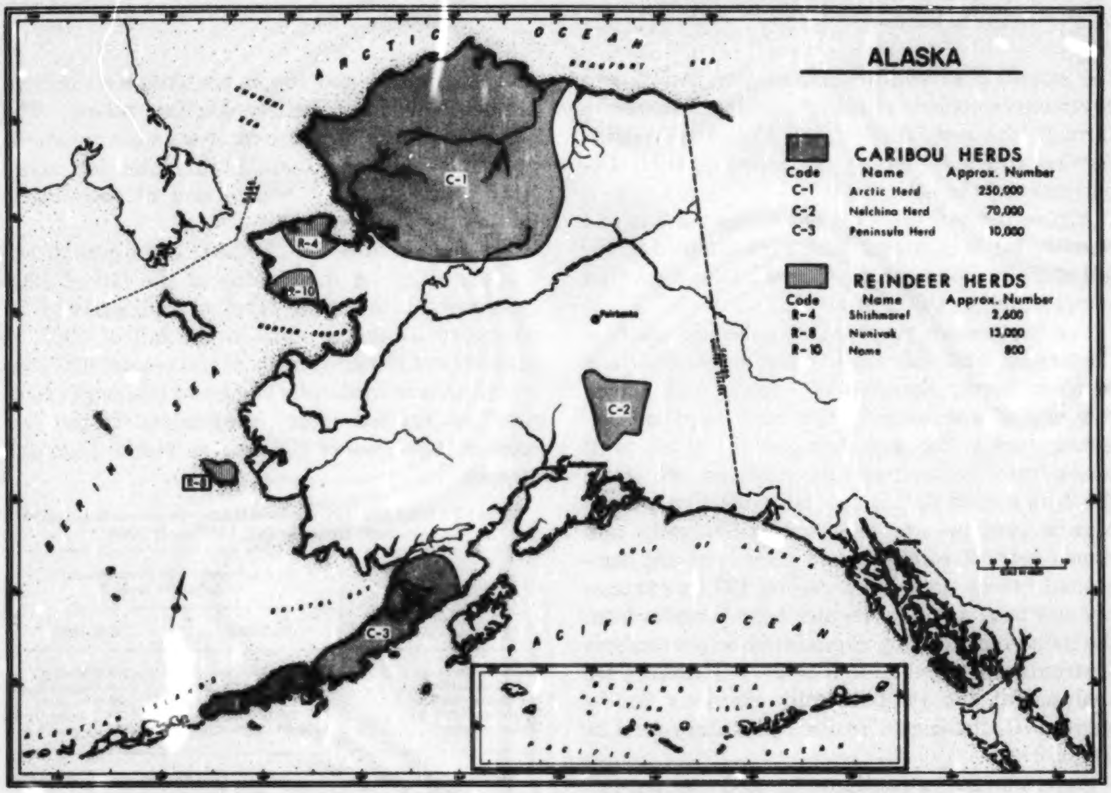
ARCTIC OCEAN
BEAUFORT SEA
ALASKA
CARIBOU HERDS
Code Name Approx. Number
C-1 Arctic Herd 250,000
C-2 Nelchina Herd 70,000
C-3 Peninsula Herd 10,000
REINDEER HERDS
Code Name Approx. Number
R-4 Shishmaref 2,600
R-8 Nunivak 13,000
R-10 Nome 800
C-1
R-4
R-10
R-8
C-2
C-3
Fairbanks
NORTON SOUND
BERING SEA
GULF OF ALASKA
PACIFIC OCEAN

Figure 1. Locations of caribou and reindeer herds sampled in Alaska

Table 1. Radionuclide concentration in muscle and rumen of Alaskan caribou and reindeer September–November 1968

Herd and sampling location[a]	Collection date 1968	Sex	Age (years)	Muscle (pCi/kg wet weight)			Rumen (pCi/kg wet weight)
				Strontium-89[b]	Strontium-90[b]	Cesium-137	Cesium-137
Arctic caribou herd Amaktuvuk Pass, C-1	10/1	F	3	13	4	4.6×10^3	5.1×10^3
	10/9	F	2			6.0×10^3	
	10/9	F	3			5.1×10^3	
	10/9	F	2			5.6×10^3	
	10/9	F	3			4.8×10^3	
Nelchina caribou herd Dickey Lake, C-2	9/11	F	9	[c]0	7	2.6×10^3	3.8×10^3
	9/11	F	5			1.5×10^3	
	9/11	F	1			3.1×10^3	
	9/11	F	9			2.0×10^3	
	9/11	M	2			2.6×10^3	
Peninsula caribou herd King Salmon, C-3	10/1	M	(d)	0	5	13.0×10^3	5.1×10^3
	10/1	F	(d)			2.5×10^3	
	10/1	F	1			1.7×10^3	
	10/3	M	(d)			5.5×10^3	
	10/3	M	(d)			4.7×10^3	
Shishmaref reindeer herd Seward Peninsula, R-4	11/12	M	3	0	21	11.0×10^3	4.9×10^3
	11/12	F	3			13.0×10^3	
	11/12	M	3			9.7×10^3	
	11/12	M	4			11.0×10^3	
	11/12	F	2			11.0×10^3	
Nome reindeer herd, R-10	11/21	M	4	0	100	1.6×10^4	1.1×10^4
	11/21	M	3			1.3×10^4	
	11/21	F	5			2.1×10^4	
	11/21	M	1			2.1×10^4	
	11/21	M	2			2.2×10^4	

[a] Sampling locations are shown in figure 1.
[b] Composite of individual samples taken within herd.
[c] All results ≤5 pCi/kg wet weight are reported as 0.
[d] Ages not available.

the sampling of additional privately owned and government-owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and the Bureau of Indian Affairs, Department of the Interior.

Figure 1 shows the locations of the caribou and reindeer herds in Alaska that were sampled in the fall of 1968. The herd at Nunivak Island was not sampled during this period.

For the present program, samples are taken in the spring and fall from selected caribou and reindeer herds. Samples of muscle and rumen contents of five animals from each herd are collected during the sampling period. Hock joint bones from five animals are collected only from the Nome herd during the fall collection period. Muscle samples are analyzed individually and rumen content samples from each herd are composited before analysis for cesium-137 by gamma-ray spectroscopy. Muscle and bone samples from the individual herd are composited before analysis of strontium-89 and strontium-90. All samples are analyzed at the Public Health Service's Southwestern Radiological Health Laboratory in Las Vegas, Nev.

Strontium-89, strontium-90, and cesium-137 data are presented in table 1 for caribou muscle, reindeer muscle, and rumen contents for the September–November 1968 collection period. The muscle data are of prime interest, since muscle is an important constituent of the diet for many Alaskan residents. A comparison of the muscle data is shown in table 2.

The data in table 2 indicates that the cesium-137 concentrations in muscle during the fall of 1968 remained at the same level of radioactivity as compared to similar data in the fall of 1967. A summary of the strontium-90 and cesium-137 concentrations in foodstuffs in Alaska (including reindeer and caribou meat) is contained in the December 1966 issue of *Radiological Health Data and Reports*.

Table 2. Cesium-137 concentrations in caribou and reindeer muscle fall 1967 and 1968

Herd	Average cesium-137 concentration (pCi/kg wet weight)	
	Fall 1967	Fall 1968
Arctic caribou	6×10^3 (October)	5×10^3 (October)
Nelchina caribou	6×10^3 (September)	2×10^3 (September)
Peninsula caribou	11×10^3 (October)	5×10^3 (October)
Shishmaref reindeer	11×10^3 (October)	11×10^3 (November)
Nome reindeer	14×10^3 (September)	19×10^3 (November)

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
March–May 1968	December 1968

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Oak Ridge Area and the Rocky Flats Plant.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Oak Ridge Area[2]

January-June 1968

Union Carbide Nuclear Company
Oak Ridge, Tenn.

Oak Ridge area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

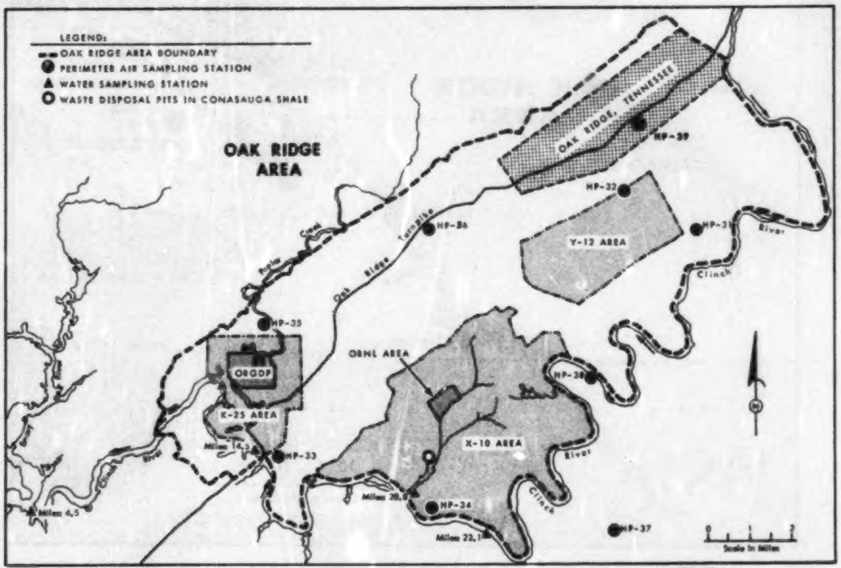
LEGEND:
OAK RIDGE AREA BOUNDARY
PERIMETER AIR SAMPLING STATION
WATER SAMPLING STATION
WASTE DISPOSAL PITS IN CONASAUGA SHALE
OAK RIDGE AREA
OAK RIDGE, TENNESSEE
HP-39
HP-32
HP-36
HP-31
Y-12 AREA
Clinch River
Oak Ridge Turnpike
Poplar Creek
HP-35
ORGDP
K-25 AREA
ORNL AREA
HP-38
X-10 AREA
Miles 14.5
HP-33
Miles 4.5
Miles 20.8
HP-34
Miles 23.1
HP-37
0 1 2
Scale in Miles

Figure 1. Oak Ridge area environmental sampling locations

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[2] Summarized from "Environmental Levels of Radioactivity for the Oak Ridge Area (Report Period. January-June 1968). Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.

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Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in tables 1 and 2. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

During the January–June 1968 surveillance period, 206 samples were collected from perimeter monitoring stations and analyzed for iodine-131. Of these, the maximum concentration detected was 0.08 pCi/m^3, the minimum was less than 0.010 pCi/m^3, and the average was 0.01 pCi/m^3. The radiation protection standard specified in the AEC Manual for iodine-131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m^3.

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area

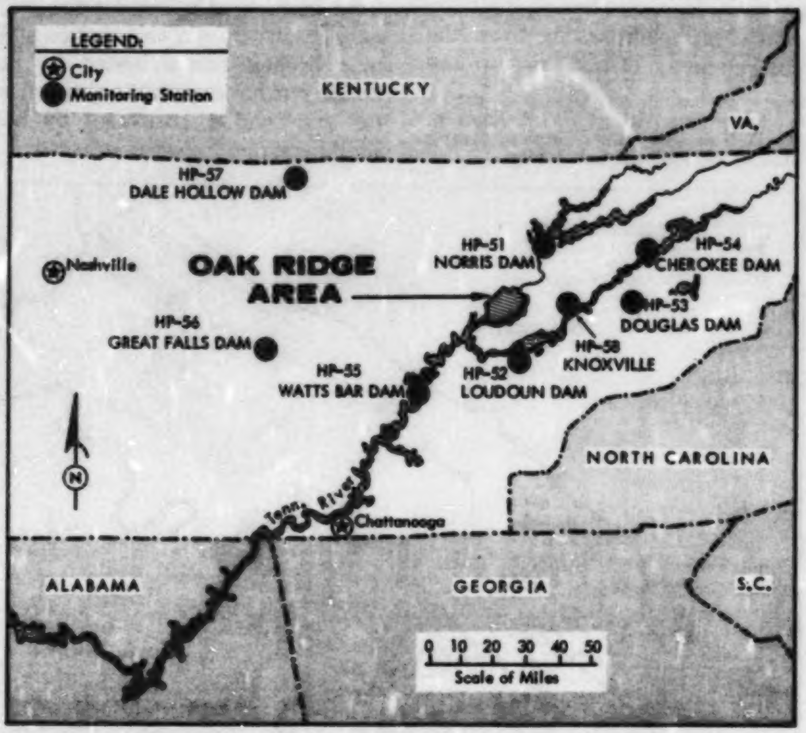
LEGEND:
City
Monitoring Station
KENTUCKY
VA.
HP-57
DALE HOLLOW DAM
Nashville
OAK RIDGE AREA
HP-51
NORRIS DAM
HP-54
CHEROKEE DAM
HP-53
DOUGLAS DAM
HP-56
GREAT FALLS DAM
HP-55
WATTS BAR DAM
HP-58
KNOXVILLE
HP-52
LOUDOUN DAM
N
NORTH CAROLINA
Tenn. River
Chattanooga
ALABAMA
GEORGIA
S.C.
0 10 20 30 40 50
Scale of Miles

Figure 2. Remote air monitoring stations, Oak Ridge area

Table 1. Long-lived gross beta radioactivity of particulates in air, Oak Ridge area January–June 1968

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard[a]	Station number (figure 2)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard[a]
HP-31	26	0.21	0.21	HP-51	26	0.24	0.24
HP-32	26	.20	.20	HP-52	26	.23	.23
HP-33	26	.18	.18	HP-53	26	.21	.21
HP-34	26	.20	.20	HP-54	26	.20	.20
HP-35	26	.21	.21	HP-55	26	.18	.18
HP-36	182	.25	.25	HP-56	26	.26	.26
HP-37	26	.17	.17	HP-57	26	.22	.22
HP-38	26	.24	.24	HP-58	25	.25	.25
HP-39	26	.22	.22				
Average		0.22	0.22	Average		0.22	0.22

[a] The applicable AEC Radiation Protection Standard is 100 pCi/m³.

Table 2. Long-lived gross alpha radioactivity of particulates in air, Oak Ridge area January–June 1968

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard[a]	Station number (figure 2)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard[a]
HP-31	26	0.002	0.10	HP-51	26	0.001	0.05
HP-32	26	.002	.10	HP-52	26	.001	.05
HP-33	26	.001	.05	HP-53	26	.001	.05
HP-34	26	.001	.05	HP-54	26	.001	.05
HP-35	26	.002	.10	HP-55	26	.001	.05
HP-36	182	.004	.20	HP-56	26	.001	.05
HP-37	26	.002	.10	HP-57	26	.002	.10
HP-38	26	.002	.10	HP-58	25	.002	.10
HP-39	26	.002	.10				
Average		0.002	0.10	Average		0.001	0.05

[a] The applicable AEC Radiation Protection Standard for natural uranium in air is 2 pCi/m³.

provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine-131 and strontium-90 detected in raw milk samples during the period are given in table 3.

Table 3. Radionuclides in raw milk, Oak Ridge area January–June 1968

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum[a]	Average
Iodine-131:			
Immediate environs	54	<10	6.7
Remote environs	<10	<10	5.0
Strontium-90:			
Immediate environs	50	5.0	21
Remote environs	34	14	20

[a] The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing a radioactivity less than this concentration.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta particle emitters, uranium, and the transuranic alpha-particle emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 4 for the period from January through June 1968.

One composite water sample from the Clinch River was analyzed for uranium during this period. For this sample, the uranium concentration was less than 1 pCi/liter, the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 2×10^4 pCi/liter.

Table 4. Concentration of major radionuclides in the Clinch River, January–June 1968

Radionuclide	Concentration (pCi/liter)		
	Location on Clinch River[a]		
	Mile 23.1[b] (Upstream)	Mile 20.8[c] (Outfall)	Mile 4.5 (Downstream)
Strontium-90	0.4	1.1	2.0
Cerium-144	.3	<.1	0.4
Cesium-137	ND	.4	1.4
Ruthenium-106	.9	.3	1.0
Cobalt-60	ND	.5	1.1
Zirconium-niobium-95	ND	.2	.3
Gross beta	1.6	21.0	6.2

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.

[b] Sampling station moved from Clinch River mile 41.5 to Melton Hill Dam CRM 23.1 about January 1, 1966.

[c] The concentrations at mile 20.8 are not measured directly but the values are calculated based on the levels of waste released and the dilution provided by the river.

ND, nondetectable.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 5 in terms of mR/hr.

Table 5. External gamma radiation levels[a] Oak Ridge area, January–June 1968

Location	Average dose rates (mR/hr)
Solway Gate	0.011
Y-12, East Portal	.011
Newcomb Road	.012
Gallaher Gate	.012
White Wing Gate	.010
Five locations	0.011

[a] The background in the Oak Ridge area, determined in 1954, was approximately 0.012 mR/hr.

Discussion of data

The average air contamination levels for gross beta radioactivity as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants (figures 1 and 2) was 0.22 percent of the maximum permissible concentration applicable to uncontrolled areas.

The average air contamination levels for gross alpha radioactivity as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.10 percent and 0.06 percent, respectively, of the AEC radiation protection standard for natural uranium which applies to populations in the neighborhood of a controlled area.

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.010 pCi/m³. This is approximately 0.01 percent of the AEC radiation standard for populations in the neighborhood of a controlled area.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge area were 6.7 pCi/liter and 5.0 pCi/liter, respectively. These levels fall within the limits of FRC Range I if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium-90 in raw milk in both the immediate and remote environs of the controlled area was approximately 21 pCi/liter. This level falls near the lower limit of FRC Range II for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of gross beta radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tenn.) were 21 pCi/liter and 6.2 pCi/liter, respectively. These values are 1.4 percent and 0.70 percent of the weighted average AEC radiation protection standards. The average concentration of transuranic alpha-particle emitters in the Clinch River at mile 20.8 was 0.023 pCi/liter which is approximately 0.01 per-

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cent of the weighted average AEC radiation protection standard.

The average radioactivity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was less than 0.01 percent of the AEC radiation protection standard for natural uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.011 mR/hr, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1967	July 1968
July–December 1967	October 1968

2. Rocky Flats Plant[1]
July-December 1968

Dow Chemical Company
Golden, Colo

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location, relative to population centers, is shown in figure 3. To assure properly controlled releases of radioactive materials to the environment, periodic samples of air, water, and vegetation are analyzed for gross alpha radioactivity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

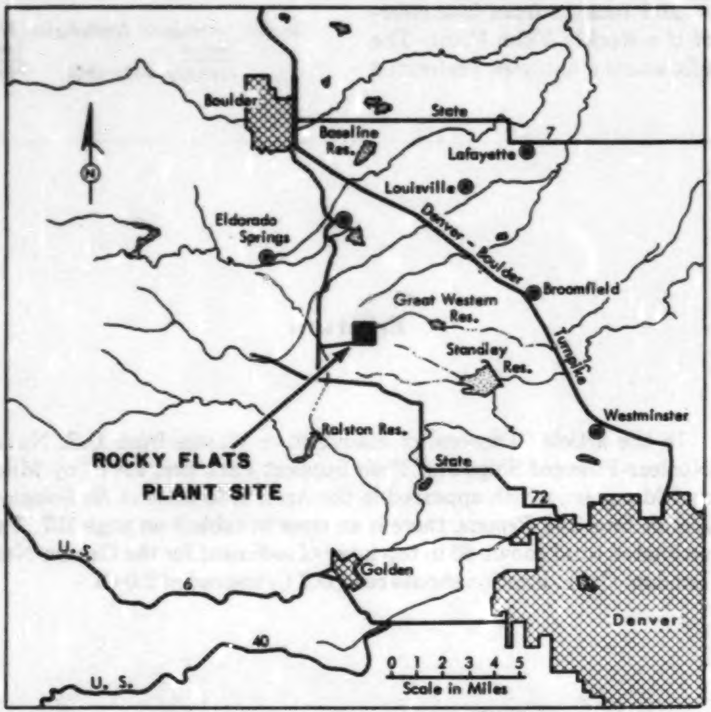
Boulder
State
7
Baseline Res.
Lafayette
Louisville
N
Eldorado Springs
Denver - Boulder Turnpike
Broomfield
Great Western Res.
Standley Res.
Westminster
Ralston Res.
ROCKY FLATS PLANT SITE
State
72
U. S.
6
Golden
Denver
40
U. S.
0 1 2 3 4 5
Scale in Miles

Figure 3. Rocky Flats Plant and environs near Denver, Colorado

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[1] Summarized from "Environmental Survey, July–December 1968," The Dow Chemical Company, Rocky Flats Division, Golden, Colo.

Air

Continuous air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha radioactivity shown in table 6 are believed to result from naturally occurring materials. All values are less than the AEC standard of 0.04 pCi/m³ for mixtures of unidentified radionuclides.

Table 6. Long-lived gross alpha radioactivity in airborne particulates, RFP environs July–December 1968

Period (1968)	Average concentration (pCi/m³)
July	0.5×10^{-3}
August	$.5\times10^{-3}$
September	.[illegible]$\times10^{-3}$
October	$.7\times10^{-3}$
November	$.4\times10^{-3}$
December	$.7\times10^{-3}$

Water

Regular water samples were obtained monthly except during the winter months from four reservoirs in the area of the Rockly Flats Plant. The results of alpha radioactivity analyses performed on these samples are given in table 7. For comparison purposes, the AEC standard for mixtures of unidentified radionuclides in water is 10 pCi/liter.

Table 7. Alpha radioactivity in water, RFP environs July–December 1968

Reservoir	Number of samples	Average concentration (pCi/liter)
Great Western	4	1.4
Standley	4	1.5
Baseline	4	0.9
Ralston	6	2.3

Vegetation

Vegetation samples collected in 1968 have been stored for analysis at a later date. A summary of these results will be included in subsequent reports.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	November 1968

Erratum

In the article "Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1967" by Miles and Mangeno, which appeared in the April 1969 issue of *Radiological Health Data and Reports*, there is an error in table 3 on page 137. The estimated total cobalt-60 in top layer of sediment for the Groton-New London, Conn. location should read 0.2 Ci instead of 2.0 Ci.

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Reported Nuclear Detonations, May 1969

The U.S. Atomic Energy Commission announced that a nuclear test of low-intermediate yield (20–200 kilotons TNT equivalent) was conducted underground on May 7, 1969 by the Atomic Energy Commission at its Nevada Test Site.

On May 16, 1969, the United States recorded seismic signals which originated from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20–200 kilotons TNT equivalent).

Announcement was also made by the U.S. Atomic Energy Commission of a nuclear test of low-intermediate yield (20–200 kilotons TNT equivalent) conducted underground at its Nevada Test Site on May 27, 1969.

Seismic signals originating from the Soviet underground nuclear test area in the Semipalatinsk region were recorded by the United States on May 31, 1969. The signals were equivalent to those of a nuclear test in the low yield (less than 20 kilotons TNT equivalent).

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

PRELIMINARY RESULTS OF SURVEYS OF 5,263 MEDICAL X-RAY FACILITIES, 1962-1967. *Bureau of Radiological Health. Radiological Health Data and Reports, Vol. 10*, June 1969, pp. 235-246.

Preliminary results of State surveys of 5,263 facilities with medical x-ray equipment are presented. Parameters such as equipment type and operating characteristics, personnel protection, workload, and certain aspects of operating technique were studied over a period from 1962 to 1967. The results of these studies will be considered together with other studies now in preparation and it is possible that some of the findings will be changed when the data are further evaluated for reporting to Congress under Public Law 90-602.

KEYWORDS: Collimation, filtration, fluoroscopic machines, healing arts, Radiographic machines, survey, United States, x-ray.

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